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# REPORT No. 1

(Belgium, France, Italy, Portugal, Spain and their Colonies)

## ON THE QUESTION OF LOCOMOTIVES OF NEW TYPES; IN PARTICULAR TURBINE LOCOMOTIVES AND INTERNAL COMBUSTION MOTOR LOCOMOTIVES (SUBJECT V FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1) (2),

By Mr. COSSART,
CHIEF ENGINEER OF THE LOCOMOTIVE WORKS OF THE FRENCH NORD RAILWAY.

**Locomotives of new types, particulary :**

1. Turbine locomotives and locomotives with engines not driving the wheels directly.
2. Locomotives driven by internal combustion engines (Diesel locomotives, Still locomotives, and similar systems).
3. High - pressure locomotives (above 20 kgr. [285 lb. per square inch]) and all locomotives having boilers differing from the usual type with a stayed firebox forming a chamber from which the gases pass into the smoke-box through smoke tubes in a barrel.

### Turbine locomotives.

No turbine locomotive is in use or under construction in Belgium, Spain, France, Italy or Portugal.

However, although the question does not appear to have had much interest for the various railway systems of these countries, even to test it experimentally, certain industrial firms have not lost sight of it.

A group of French locomotive builders (Messrs Schneider & Co., Paris, the Société Alsacienne de Constructions Mécaniques, Belfort, and the Compagnie de Fives-Lille, Paris) after following very closely the trials made in Switzerland of the turbine locomotive designed by Mr. Zoelly, General Manager of the Escher Wyss Company, prepared a design for adapting the Zoelly system to a locomotive of the *Pacific* type with a boiler pressure of 16 kgr. (227.6 lb. per square inch) belonging to one of the French railway systems.

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(1) This question runs as follows : « Locomotives of new types; in particular, turbine locomotives and internal combustion motor locomotives. Construction, efficiency, use und repair ».

(2) Translated from the French.

This locomotive has never been built.

The design provides for two turbines, as the main driving engine, one for running forward and the other for running backward, mounted on the same shaft and driving the second coupled axle through a double reduction gear, a jack shaft, cranks, and connecting rods. The steam, after doing work in the turbines, passes into a water-tube condenser situated on the transverse axis of the bogie. An auxiliary group fixed under the boiler barrel, between the second and third coupled axles, comprises a single turbine driving : 1. a centrifugal pump, called the circulating pump, which draws water from the tender and forces it through the condenser tubes back again to the tender; 2. two centrifugal pumps working in series, one the condensate pump and the other the boiler feed water pump; 3. a centrifugal pump feeding the water ejector for exhausting the air from the condenser.

In the forward extension of the boiler (of the normal type) is placed, the smokebox, which in turn ends in the feed-water pre-heater. This consists of a cylinder set horizontally containing tubes through which the combustion gases pass after leaving the boiler tubes; the feed water surrounds the tubes. The draught is created by a turbo-fan. The engine is fitted with two regulators, one in the steam dome before the steam passes into the superheater, the other, on the superheated side in front of the turbine valve chest. In this way, even when the locomotive is not running, superheated steam can be supplied to the auxiliary group. The turbine valve chest fulfils the same functions as the reversing gear of an ordinary locomotive. The admission of steam may be varied or the locomotive may be reversed by means of the set of valves contained in the valve chest and operated from the engine cab.

The main turbines are of the Zoelly type the fore gear having 7 wheels, and the back gear three wheels; at 90 km. (55.9 miles) per hour the turbine speed is 6 800 revolutions per minute. With an admission pressure of 15 kgr. (213 lb. per sq. inch) absolute, a temperature of 350° C. (662° F.) and a condenser vacuum of 85 %, the total steam consumption would be 8 600 kgr. (18 960 lb.) per hour for 2 000 H. P.

All the parts requiring perfect centering and great accuracy in their relative positions, such as the turbines and speed-reduction gear, are erected beforehand on a monoblock sub-frame which is afterwards secured in position on the main frames.

The turbo-fan for the induced draught is provided with two sets of nozzles. One set is fed by steam bled from the main turbine in such a way that the draught producted is proportionate to the consumption of steam; the other is fed with live steam when it is necessary to maintain the draught while the locomotive is standing.

The heated water from the condenser is cooled in the cooling tender where the water trickles over beds of « Raschig » rings through which air is drawn by a turbo-fan group. This turbo-fan group is driven by live steam which on exhausting is used in a second stage to drive the turbine of the auxiliary group, after which it passes to the condenser.

Unlike the Zoelly locomotive, this design does not provide for an air preheater, the authors being of the opinion that the complication introduced by this apparatus, and its maintenance, would hardly compensate for the saving in fuel which it might bring about.

The detailed design has been carried very far, ease of inspection of the working parts being always kept in mind.

*Mechanical particulars of the main turbines under different loads.*

| | |
|---|---|
| Absolute pressure of steam at the turbines . . . . . . . | 15 kgr. (213.3 lb. per squ. inch). |
| Temperature of steam. . . . | 350° C. (662° F.). |
| Condenser vacuum . . . . . . | 85 to 88 %. |

With the turbine running at normal speed, the results anticipated, for forward running, are as follow :

| | | | | During overload. |
|---|---|---|---|---|
| Total quantity of steam in kgr. (in lb.) per hour | 8 600<br>(18 960) | 6 450<br>(14 220) | 4300<br>(9 480) | 10 800<br>(23 810) |
| Quantity of steam required for the auxiliary group in kgr. (in lb.) per hour. | 900<br>(1 984) | 675<br>(1 488) | 450<br>(921) | ... |
| Vacuum °/₀. . . . . . . . . . . . | 85 | 87 | 88 | ... |
| Speed, revolutions per minute. . . . . | 6 800 | 6 800 | 6 800 | ... |
| Horse-power, at turbine shaft. . . . . | 2 000 | 1 445 | 900 | ... |
| Steam consumption in kgr. (in lb.) per H. P. | 4.3<br>(9.5) | 4.46<br>(9.83) | 4.78<br>(10.54) | ... |
| Tractive effort at 90 km.(55.9 miles) per hour and 6800 revolutions per minute, kgr. (lb). | 6 000<br>(13 328) | 4 335<br>(9 557) | 2 700<br>(5 952) | ... |
| Tractive effort on starting, kgr. (lb). | 12 000<br>(26 455) | 8 200<br>(18 078) | 5 050<br>(11 333) | 14 200<br>(31 306) |

*Particulars of the auxiliary appliances.*

| | |
|---|---|
| 1. Power absorbed by the circulating pump . . . | 42.4 H. P. |
| Power absorbed by the condensed - water extraction pump . . . . | 1.2 H. P. |
| Power absorbed by the feed pump . . . . . . . | 8.5 H. P. |
| Power absorbed by the ejector . . . . . . . . . | 20.6 H. P. |
| 2. Power of the turbine of auxiliary group. . . . | 80 H. P. |
| Hourly steam consumption (turbine in series with the water cooling fan) . . . . . . . . | 900 kgr. (1 984 lb.) |
| 3. Normal power of the induced draught fan turbine . . . . . . . . . | 45 H. P. |
| Normal vacuum. . | 170 mm. (6.693 inches) |
| Normal capacity. . | 8.5 m³ (300 cubic feet). |

*Particulars of the cooler.*

| | |
|---|---|
| Cooling surface. . . . . | 54 m² (581 sq. feet). |
| Height of layers . . . . . | 20 cm. (8 inches). |
| « Raschig » rings. . . . | 15 mm. (5/8 inch) in diameter. |
| Air flow . . . . . . . . | 46 m³ (1 624 cubic feet) per second. |
| Water flow . . . . . | 680 m³ (24 015 cubic feet) per hour. |
| Condenser surface. . . | 250 m² (2 691 sq. feet). |

This cooler with atmospheric air at a temperature of 20° C. (68° F.) and a hygroscopicity of 60 % ought to ensure a vacuum of 85 % when the cooler removes $5.5 \times 10^6$ calories per hour which corresponds to about 2 000 H.P.

*Particulars of the fan turbine designed for a cooling capacity of $5.5 \times 10^6$ calories per hour.*

| | |
|---|---|
| Capacity of fan. . . . | 46 $m^3$ (1 624 cubic feet) per second. |
| Normal vacuum . . . . | 41 mm. (1.614 inch). |
| Power absorbed by the turbo-fan group. . . | 47 H. P. |
| Steam consumption (turbine in series with the pump turbine) . . . . . . . . . | 900 kgr. (1 984 lb.) per hour. |

The « Société de Construction des Batignolles », Paris, who hold the French rights of the Ljungström patents has designed a 2 000 H. P. locomotive of this type with a boiler having a working pressure of 20 kgr. (284.5 lb. per sq. inch).

This engine has never been built.

The design is an adaptation of the Ljungström patents to the traction conditions of express trains on French railway systems. The locomotive is composed of 2 vehicles. The first, carried on a bogie and 3 independent axles, carries the boiler and auxiliaries. The second, carried on three coupled axles and a bogie is the motor vehicle proper. It carries the main turbine, the condenser, and the cooler. The main turbine consists of a wheel with one set of vanes, and of a reaction wheel. The steam is admitted at a pressure of 18 kgr. (256.1 lb. per sq. inch) through three separate nozzles, the valves of which are operated by an oil servo-motor. The motion of the turbine is transmitted to the axle through the medium of flexible couplings, toothed reduction gearing, and a quill shaft surrounding the axle and connected to the wheels of this axle by a special system of short rods. The engine is reversed by means of a servomotor which disengages two of the wheels of the speed reduction gear and meshes with them two intermediate pinions.

The boiler, of the locomotive type, is provided with a regulator which admits steam to the superheater. This superheater steam is intended for the main turbine and the four auxiliary turbines : two turbines each driving a condenser pump and a feed pump, a turbine driving the cooling fans, and the turbine driving the induced draught fan. A steam pipe supplies saturated steam to the condenser air ejector, the air-brake pump, the servo-motor of the fire door, and for heating the train.

The smoke-box contains the induced draught apparatus and the air pre-heater. The air pre-heater is of the industrial rotary Ljungström type.

The condenser, the water cooler, the feed-pumps, the two-stage feed-water preheater (a low-pressure stage and a high-pressure stage), the induced draught turbo-fan are similar to those employed on other Ljungström locomotives.

The particulars of this locomotive are :

| | |
|---|---|
| Grate area . . . . . . . . . . . . . . . . . . . | 3.5 $m^2$ (37.7 sq. feet). |
| Heating surface of the firebox . . . . . . . . . | 15.8 $m^2$ (170 sq. feet). |
| Heating surface of tubes . . . . . . . . . . . . | 132.0 $m^2$ (1 421 sq. feet). |
| Total heating surface . . . . . . . . . . . . . | 147.8 $m^2$ (1 591 sq. feet). |
| Superheater surface . . . . . . . . . . . . . . | 80.0 $m^2$ (861 sq. feet). |
| Boiler working pressure . . . . . . . . . . . . | 20 kgr./$cm^2$ (284.5 lb. per sq. in.). |

| | |
|---|---|
| Cooling surface of condenser | 2 400 m² (25 835 sq. feet). |
| Diameter of driving wheels | 1.600 m. (5 ft. 3 in.). |
| Weight, empty | 135 metric (132.9 Engl.) tons. |
| Weight, in working order | 159 metric (156.5 Engl.) tons. |
| Adhesive weight | 55.5 metric (54.6 Engl.) tons. |
| Maximum power | 2 300 H. P. |

### Locomotives with engines not driving the wheels directly.

No locomotive of this type is in use, is being built or is even contemplated in Belgium, Spain, France, Italy, Portugal or their Colonies.

### Diesel locomotives.

The military requirements during the 1914-1918 war resulted in a very extensive use of petrol locomotives. After the cessation of hostilities the railway systems of those countries which took part in the operations, having become short of shunting locomotives, purchased the available petrol locomotives for duty in small stations. Manufacturers having private sidings considered this type of locomotive more practical and more economical than the steam locomotive for intermittent service and for short distances. Light railways and even some main line systems have placed orders with the firms building petrol locomotives for rail motors for certain special duties. At the present time a considerable number of these petrol tractors are in existence.

The price of petrol, however, becomes prohibitive when it is a question of motors of great power, and above 150 or 200 H. P. the petrol engine should undoubtedly be replaced by an engine of the Diesel type. It would be interesting to discuss these petrol locomotives and rail motor coaches, for they are the prototypes of the Diesel locomotives or Diesel rail motor cars, but such a discussion is outside the scope of this report.

At the present time if the replies are correct, in the countries which have been allotted to me for the compilation of this report, the only locomotives fitted with Diesel engines are the following:

1 locomotive of 120 H. P. and 1 locomotive of 250 H. P. belonging to the Tunisian Railway Company:

1 Fiat rail motor coach of 180 H. P. on the Firenze-Faenza line (Italy);

1 Beardmore rail motor coach of 200 H. P. on the Pampelune-San Sebastian line (Spain);

1 Ansaldo locomotive on the Italian State Railways (on trial).

On the other hand, designs have been completed and the construction is about to be taken in hand by the following group of firms: Forges et Aciéries de la Marine et d'Homécourt, and the Compagnie Française de Matériel de Chemins de fer, of Paris, for locomotives of 250 to 1 700 H. P.; by Messrs Schneider & Co. (Le Creusot) of Paris, for one of 200 H. P.; and by the Fiat Co. of Turin for rail motor coaches of 150 to 300 H. P., and locomotives of 150 to 600 H. P.

The power transmission in all these machines is electrical, except in that designed by Messrs Schneider & Co. who prefer mechanical transmission. These various locomotives and rail motor coaches will now be described in turn.

### Locomotives of the Tunisian Railway Company.

In 1923 the Tunisian Railway Company (1-m. = 3 ft.-3 3/8 in. gauge) put into service, by way of trial, a Diesel electric locomotive furnished by the Diesel-Electricka Wagn Aktiebolaget, Västeras, represented in France by the Etablissements de Matériel Naval et Industriel. This firm was selected on account of the results obtained with similar locomotives built by them, and in service since 1914.

The following are the particulars of this locomotive :

| | |
|---|---|
| Over-all length over buffers . . . . . . . . . . . | 10.540 m. (34 ft. 7 in.). |
| Total wheel base . . . . . . . . . . . . . . | 7.000 m. (22 ft. 11 5/8 in.). |
| Distance between bogie centers . . . . . . . . | 5.000 m. (16 ft. 5 in.). |
| Bogie wheel base . . . . . . . . . . . . . . | 2.000 m. (6 ft. 6 3/4 in.). |
| Total weight empty . . . . . . . . . . . . . . | 29.380 metric (28.9 Engl.) tons. |
| Total weight in working order and adhesive weight . | 30 metric (29.5 Engl.) tons. |
| Wheel diameter . . . . . . . . . . . . . . . . | 0.800 m. (2 ft. 7 1/2 in.). |
| Fuel carried . . . . . . . . . . . . . . . . . | 360 litres (79.2 British gallons). |
| Water carried . . . . . . . . . . . . . . . . | 260 litres (57.2 British gallons). |

The engine is a 6-cylinder, single-acting, four-stroke cycle Diesel engine. The cylinders are arranged in the form of a V, are 200 mm. ( 7 7/8 inches) in diameter with a stroke of 240 mm. (9 7/10 inches). The power is 120 H.P. The shaft has three cranks and turns in a casing forming the engine frame.

Each cylinder is fitted with three valves, one for the injection of the heavy oil by means of compressed air, the second for the admission of combustion air, and the third for the exhaust. The cylinders are water-cooled. The compressed air required for the injection is provided by a compressor driven by the engine. A cylinder which is filled automatically while the engine is running, provides the compressed air for the injection when starting, which is done electrically.

The heavy oil is fed into the injection air by means of a small pump regulated by a centrifugal governor in such a fashion that the amount of oil pumped is always proportionate to the load on the engine.

Forced lubrication is employed for the mechanism; the cylinders are not lubricated specially, since the heavy oil itself ensures this.

A circulation pump ensures a flow of cooling water which, after leaving the cylinder jackets, passes into a radiator on the roof of the locomotive, and from there to the tank.

The electric generator is mounted on an extension of the engine shaft, being connected to the engine by a flexible coupling. It is of variable voltage (maximum 550 volts), but it gives a constant output of work whatever the load or the speed. It is automatically cut out of action if the power required is greater than 80 kw. This dynamo is built with 8 shunt-wound poles; when starting up, it is used as a motor and for this purpose it is provided with 8 other pole pieces. Each of the four axles of the locomotive is driven by a motor through the medium of nickel steel toothed gears. If one motor breaks down, it may be cut out of the circuit so that the locomotive can run on the other three.

The locomotive has two driver's cabs in each of which is a controller similar in pattern to that employed on electric trams. In driving a handle is used for controlling the direction of running and puts the axle motors in series or in parallel, and a small handle which works in the same way as the control handle on the trams. This handle is fitted with a device by which it is returned automatically to zero if the driver releases it.

The locomotive is fitted with a fuel tank enabling a run of 800 km. (500 miles) to be made without refuelling.

In actual service, the average consumption on lines with gradients of 0 to 20 mm. (0 to 1 in 50) has been about 7 gr. per tonne-kilometre (6.46 drams per Engl. ton-mile) (including the weight of the locomotive) and 13 gr. per tonne-kilometre (12 drams per Engl. ton-mile) hauled.

The Tunisian Railway Company estimates that the Diesel locomotive represents a saving of about 50 % in fuel alone as compared with the steam locomotive.

In view of these results the Tunisian Railway Company, in 1924, placed an order with the Compagnie de Constructions Mécaniques of Paris (Sulzer Systems) for a 250 H. P. Diesel locomotive of metre gauge mounted on two four-wheeled bogies for a maximum speed of 60 km. (37.3 miles) per hour. The Compagnie de Constructions Mécaniques provided the Diesel engine, and entrusted the construction of the mechanical portion to the Compagnie Française de Matériel de Chemins de fer and that of the electrical portion to the Compagnie Electro-Mécanique in collaboration with the Brown-Boveri Company.

The following are the particulars of this locomotive :

| | |
|---|---|
| Total length over buffers . . . . . . . . . . . | 9.360 m. (34 feet). |
| Total wheel-base . . . . . . . . . . . . . . . | 6.150 m. (20 ft. 2 1/8 in.). |
| Distance between bogie centers . . . . . . . . . | 4.250 m. (14 ft. 11 5/16 in.). |
| Bogie wheel base . . . . . . . . . . . . . . . | 1.900 m. (6 ft. 2 13/16 in.). |
| Total weight empty . . . . . . . . . . . . . . | 36 860 kgr. (81 260 lb.). |
| Total weight in working order and adhesive weight . . | 38 700 kgr. (85 320 lb.). |
| Wheel diameter . . . . . . . . . . . . . . . . | 0.840 m. (2 ft. 9 3/32 in.). |
| Fuel supply . . . . . . . . . . . . . . . . . | 900 litres (198 British gallons). |
| Water supply . . . . . . . . . . . . . . . . | 1 000 litres (220 British gallons). |

The Sulzer Diesel engine has 8 single-acting, four-stroke cycle cylinders arranged in the form of a V, 215 mm. (8 15/32 inches) in diameter and 300 mm. (11 53/64 inches) stroke. It has no air-injection compressor, but differs from airless-injection Diesel engines by the fact that the fuel, before admission into the cylinder, is partially burnt in a special chamber of small dimensions. The resulting rise in pressure ensures the atomisation of the fuel. A governor acts on the fuel pump.

The driver is able to stop the engine from the cab by means of an electro-magnet which holds open the air-inlet valves, thus putting the fuel pump out of action.

The cylinders of the engine are water-cooled, the cooling water passing through a tubular cooler divided into six groups. These groups of tubes are arranged in the form of a hexagon round an electric fan. Any number of these groups may be put in service according to the temperature of the surrounding atmosphere so that the water returns to the engine at a relatively constant temperature.

The direct-current generator is coupled directly to the engine. It is rated at

145 kw. and feeds the traction motors, with Ward-Leonard coupling, at a voltage varying from 380 to 750 volts. The exciter, rated at 26 kw. and 150 volts is mounted on the upper part of the generator by which it is belt driven. The generator is provided with a special excitation-winding fed by an accumulator battery enabling it to work as a series motor for starting the Diesel.

The four traction motors are slung by the nose and each of them drives one of the axles by gears with a 16/71 ratio. Their power is 47 kw. at the hourly rate at 400 volts and 840 revolutions per minute, that is to say at 30 km. (18.6 miles) per hour. They are permanently coupled two by two in parallel, but these two groups may themselves be put in series or in parallel. The motors are of the self ventilated type : a double fan mounted on the pinion side of the rotor draws the outside air through protected gratings in the upper part of the armature bearing shields, and return it to the atmosphere through an opening provided with baffles in the lower part of the casing. The rotor shaft revolves in roller bearings.

The control equipment comprises a reverser driven by a small motor and three contactors, one for series running, and two for parallel running. Acceleration is obtained by gradually cutting out the excitation resistance of the exciter, which is effected, as is the control of the series-parallel coupling, by the main handle of the controller, which has twenty positions.

A second handle controls the reverser. This equipment includes a device by which the main handle of the controller automatically returns to zero when released by the driver.

This locomotive should be able to draw a load of 80 t. (78.7 Engl. tons); on the level at 60 km. (37.3 miles) per hour; up a gradient of 5 mm. (1 in 200) at 37 km. (23 miles per hour); up a gradient of 10 mm. (1 in 100) at 26 km. (16.6 miles) per hour; up a gradient of 15 mm. (1 in 67) at 19 km. (118 miles) per hour; and as regards adherence it had to be able to draw a load of 124 t. (122 Engl. tons) up a gradient of 15 mm. (1 in 67). During the trials these requirements were amply exceeded since a load of 126 t. (124 Engl. tons) was drawn up- a gradient of 15 mm., 2 km. (1.24 miles) long at a steady speed of 17 km. (10.6 miles) per hour without any slipping.

The usual consumption of crude oil with a calorific value of 10 791 calories (42 820 B. T. U.) is about 7.2 gr. per t.-km. (6.65 drams per Engl. ton-mile) of the total weight of the train, and 9.8 gr. per t.-km. (9 drams per Engl. ton-mile) of the weight drawn.

### Locomotives, locomotive brake vans, and rail motor coaches of the :

### « *Forges et Aciéries de la Marine et d'Homécourt — Compagnie Française de Matériel de Chemins de fer* » *group of firms.*

As a result of the success achieved with the 250-H. P. locomotive of the Tunisian Railway Company, the mechanical part of which locomotive had been constructed by the Compagnie Française de Matériel de Chemins de fer, the last-mentioned firm entered into an agreement with the Société des Forges et Aciéries de la Marine et d'Homécourt with the object of setting up a department for research into locomotive traction questions and to investigate electric Diesel locomotives of all powers intended both for standard and for narrow gauge tracks. Seventeen different designs have been evolved and could be built at any time. Although no locomotive or rail motor coach has yet been built, it would not be without interest to say a few words regarding these designs, because they illustrate very clearly the possibility of utilising internal combustion motors for powerful locomotives. There are four designs for standard-gauge locomotives with an output at the Diesel engine shaft of 560, 700, 1 700, and 1 700 H. P. respectively; six designs for metre gauge locomotives with an output at the Diesel engine shaft of 250, 330, 330, 560, 900, and 1 120 H. P.; two designs for 0.600-m. (2 ft. 11 5/8 in.) locomotives of 250 and 330 H. P.; three designs for standard gauge rail motor vans of 330, 420, and 440 H. P.; and two designs for standard gauge rail motor coaches of 250 and 330 H. P.

To be exact the locomotives above 850 H. P. consist of two Diesel engine elements coupled together thus forming a double traction unit, but the whole is operated by one man in either of the driver's cabs situated at one end of each motor element.

The particulars of the most powerful engines of each of the above classes are as shown in the table, page 2406.

The Diesel engines provided in these designs are of the Sulzer type. The connexion between engine and axles is formed by electrical transmission. The traction motors are of the slung type although, for powers exceeding 300 to 400 H. P. per axle-motor, provision has been made in certain cases for the Sécheron type of double motor with separate control. The regulation of the speed is based on the principle of the Ward-Leonard coupling, in which the tension at the generator terminals, and consequently the speed of the motors, is regulated by varying the excitation of the generator, to do which it is merely necessary to operate the controller handle. The capacity of the Diesel engine is regulated automatically by a centrifugal governor, by which the speed of the engine is maintained constant to within about ± 5 % under any load.

When the engine is started, the generator, being supplied with current from a battery of accumulators, works as a series motor owing to the provision of a special excitation winding. The exciter, which is mounted on the end of the generator shaft, provides in addition to the exciting current, the battery charging current and the current for the auxiliary appliances, such as the compressor motors, the fans, lighting circuit, etc. When the engine is not running, the circuits of the auxiliary appliances obtain their current from the battery alone.

The controlling and measuring apparatus installed in the cabs comprise :

1 starting and stopping handle for the Diesel engine;

1 reversing handle;

1 controller with a large number of contacts, thus allowing of a very gradual regulation of the speed;

The controlling gear of the auxiliary circuits;

The measuring apparatus (wattmeter, voltmeters, ammeters).

The controlling apparatus is combined so that the locomotive may be driven by one man. When the locomotive is running the driver must always exert a pressure on the controller handle or, with his foot, on a pedal arranged in the cab floor, otherwise the protection relays come into operation, causing the vehicle to come to a standstill by the action of an electromagnetic brake-valve.

The reduction gear ratio is generally selected so as to allow the motor to attain a peripheral speed of about 30 m.

| | Locomotives. | | | Motor van. | Rail motor car. |
|---|---|---|---|---|---|
| Track gauge . . . . . . . | 1.44 m.<br>(4 ft. 8 5/8 in.) | 1.00 m.<br>(3 ft. 3 3/8 in.) | 0.60 m.<br>(1 ft. 11 5/8 in.) | 1.44 m.<br>(4 ft. 8 5/8 in.) | 1.44 m.<br>(4 ft. 8 5/8 in.) |
| Horse-power at Diesel engine shaft. | 1 700 | 1 120 | 330 | 440 | 330 |
| Type of machine . . . . . | 2 C + C 2 | 1 D + D 1 | 1 C + C 1 | 2 — AA | 2 — AA |
| Length between buffers . . . | 23.900 m.<br>(78 ft. 5 in.) | 19.880 m.<br>(65 ft. 2 3/4 in.) | 13.512 m.<br>(50 ft. 10 3/4 in.) | 14.650 m.<br>(48 ft. 13/16 in.) | 19.700 m.<br>(64 ft. 7 19/32 in.) |
| Total wheel base . . . . . . | 20.300 m.<br>(66 ft. 7 1/4 in.) | 16.680 m.<br>(54 ft. 8 3/4 in.) | 11.430 m.<br>(37 ft. 6 in.) | 11.050 m.<br>(36 ft. 3 in.) | 15.300 m.<br>(50 ft. 2 3/8 in.) |
| Rigid wheel base . . . . . | 3.900 m.<br>(12 ft. 9 9/16 in.) | (4.440 m.)<br>(14 ft. 6 13/16 in.) | 1.880 m.<br>(6 ft. 2 in.) | 2.300 m.<br>(7 ft. 6 9/16 in.) | 2.500 m.<br>(8 ft. 2 7/16 in.) |
| Minimum radius of curves . . | 120 m.<br>(6 chains) | 120 m.<br>(6 chains) | 50 m.<br>2 1/2 chains) | 100 m.<br>(5 chains) | 120 m.<br>(6 chains) |
| Total weight in service, kgr. (lb.). | 155 000<br>(341 720) | 114 000<br>(251 330) | 51 850<br>(114 310) | 57 to 65 000<br>(125 660<br>to 143 300) | 56 to 61 000<br>(123 460<br>to 134 480) |
| Empty weight in kgr. (in lb.). | 149 400<br>(329 370) | 110 000<br>(242 510) | 49 900<br>(108 030) | 55 100<br>(121 470) | 54 200<br>(119 490) |
| Adhesive weight, in kgr. (in lb.). | 103 500<br>(228 180) | 96 000<br>(211 640) | 42 200<br>(93 030) | 35 000<br>(77 160) | 24 800 to 28 400<br>(54 670 to 62 610) |
| Diameter of driving wheels . | 1.250 m.<br>(4 ft. 1 3/16 in.) | 1.050 m.<br>(3 ft. 5 5/16 in.) | 0.762 m.<br>(2 ft. 6 in.) | 1.000 m.<br>(3 ft. 3 3/8 in.) | 1.050 m.<br>(3 ft. 5 5/16 in.) |
| Diameter of carrying wheels . | 1.000 m.<br>(3 ft. 3 3/8 in.) | 0.840 m.<br>(2 ft. 9 in.) | 0.533 m.<br>(1 ft. 9 in.) | 1.000 m.<br>(3 ft. 3 3/8 in.) | 1.050 m.<br>(3 ft. 5 5/16 in.) |

(98 1/2 feet) per second, consistent with a motor of economical design.

The efficiency of the electrical transmission, that is to say, the proportion of the power, produced by the Diesel engine, that is developed at the wheel rim, is about 82 %.

The auxiliary services absorb roughly another 10 % of the energy provided by the engine.

### Schneider locomotives and rail motor coaches.

Having built a large number of petrol-driven locomotives and rail motor coaches of 60 to 85 H. P., the Schneider Co. realized the interest attaching to the use of a more powerful engine running on a cheaper fuel than petrol. They have designed, therefore, a machine capable of drawing light trains under economic conditions.

For this purpose they propose a 200-H. P. Diesel engine, running at the relatively high speed of 800 revolutions per minute. They have also selected mechanical transmission as giving generally a locomotive of the minimum of weight for the maximum output. A special arrangement which is discussed later, renders this mechanical transmission possible with such powers as this.

The motor is a four-stroke cycle, six-cylinder Diesel engine with compressed-air fuel injection. A six-cylinder type has been selected in order to improve the balance and to facilitate starting. A high running speed is facilitated by slightly increasing the pressure of the combustion air admitted to the cylinder, and the reduced weight of the engine has been obtained by judiciously lightening the portions subject to fatigue and wear.

The engine is equipped with the usual accessories for fuel injection and for starting. A small hand-operated air compressor may, if occasion requires, serve as a breakdown apparatus to fill the compressed-air cylinder for starting the engine in case of a failure in the ordinary compressed air supply.

The starting gear is formed of two distinct fittings, one of which ensures that slipping takes place automatically in the drive when starting, and also ensures a non-slip drive when the locomotive is running, while the other enables the drive to be disconnected at will from the transmission in order to reverse the locomotive. The first is the Fieux clutch. This is a spiral friction clutch in which the pressure on the friction drum is governed by the combined action of the driving couple and the centrifugal force. Complete connexion is automatically effected once the couple developed by the engine overcomes the resistance, and on the other hand the clutch begins to slip automatically as soon as the resistance becomes excessive. This automatically prevents the engine stalling, and makes the starting gradual, whatever resistances are to be overcome, consistent with the power available. The Fieux friction clutch has proved satisfactory and has given excellent results on the Schneider petrol rail motor coaches.

The mechanism which comes after the clutch is of special design in order to enable the sliding gear train, the simplicity, endurance, and efficiency of which are well-known, to be applied to an engine of this power.

The difficulty of operating a sliding gear speed change train increases with the power which is to be transmitted, this difficulty being due to the inertia of the elements which are keyed on to the main shaft, and which are required to change their angular velocity suddenly when the gears are changed. The energy which is absorbed by, or has to be furnished to, this arrangement has the value

$$\frac{I\omega^2}{2} - \frac{I\omega_1^2}{2}$$

I being the total moment of inertia of the elements on the main shaft and $\omega$. and $\omega_1$ the successive speeds of this shaft when changing the gear. By reducing this value as much as possible the ease of manipulating the change of speed is correspondingly increased.

In the arrangement adopted $\omega - \omega_1$ has been dealt with by increasing the number of changes of speed, which also enables the motive power to be better utilized. On the other hand I has been reduced in the following manner : The main shaft is provided with two pinions only, of very small diameter, owing to the use of three secondary shafts each provided with a sliding gear of two pinions and a fixed pinion engaging with a gear wheel on the driven shaft. It is possible, therefore, to give to the driven shaft two × three different speeds. In addition a dog clutch permits of a direct drive from the principal shaft to the transmission shaft. Under these conditions, and despite the fact that there are seven possible speeds, the moment of inertia of the elements on the principal shaft is as low as possible. In this way a mechanism has been realized which, for 200 H.P. at 800 revolutions per minute should be easier to manipulate than a mechanism with 4 speeds for 60 H.P. at 1 000 revolutions per minute of the classical design. This advantage, coupled with those of the Fieux friction clutch ought to result in a very interesting machine. The Schneider Co. suggest this design can be used either as a motor brake van, or as a loco-tractor.

The following tables give the results which, it is hoped, will be obtained in the two cases :

### I. — *Motor brake van.*

Empty weight : about 26 t. (25.6 Engl. tons).

Speeds variable in steps between 7.5 km. and 75 km. (4.66 and 46.6 miles) per hour, for an engine speed of between 570 and 800 revolutions per minute.

| — | Running conditions anticipated for rail motor coach + train of : | | |
|---|---|---|---|
| | 50 t. (49.2 Engl. tons). | 70 t. (68.9 Engl. tons). | 90 t. (88.6 Engl. tons). |
| Level . . . . . . . . . . | 75 km. (46.6 miles per hour). | 55 km. (34.2 miles per hour). | 55 km. (34.2 miles per hour). |
| Gradient of 4 mm. (1 in 250) . . | 55 km. (34.2 miles per hour). | 39 km. (24.2 miles per hour). | 39 km. (24.2 miles per hour). |
| — 8 mm. (1 in 125) . . | 39 km. (24.2 miles per hour). | 36 km. (22.4 miles per hour). | 29 km. (18 miles per hour) |
| — 12 mm. (1 in 83) . . | 30 km. (18.6 miles per hour). | 25 km. (15.5 miles per hour). | 21 km. (13 miles per hour). |
| — 16 mm. (1 in 63) . . | 24 km. (15 miles per hour). | 21 km. (13 miles per hour). | 15 km. (9.3 miles per hour). |
| — 20 mm. (1 in 50) . . | 20 km. (12.4 miles per hour). | 14 km. (8.7 miles per hour). | 12 km. (7.5 miles per hour). |

## II. — *Loco-tractor.*

Weight in working order : about 32 t. (31.5 Engl. tons); speed variable in steps between 5.6 km. and 55.3 km. (between 3.5 and 34.5 miles) for an engine speed of between 570 and 800 revolutions per minute.

| — | Running conditions anticiped for loco-tractor + train of : | | |
|---|---|---|---|
| | 70 t. (68.9 Engl. tons). | 90 t. (88.6 Engl. tons). | 110 t. (108.3 Engl. tons). |
| Level | 55 km. (34.2 miles per hour). | 55 km. (34.2 miles per hour). | 55 km. (34.2 miles per hour). |
| Gradient of 4 mm. (1 in 250) | 40 km. (24.8 miles per hour). | 40 km. (24.8 miles per hour). | 39 km. (24.2 miles per hour). |
| — 8 mm. (1 in 125) | 32 km. (20 miles per hour). | 28 km. (17.4 miles per hour). | 24 km. (15 miles per hour). |
| — 12 mm. (1 in 83) | 28 km. (17.4 miles per hour). | 22 km. (13.8 miles per hour). | 16 km. (10 miles per hour). |
| — 16 mm. (1 in 63) | 22 km. (13.8 miles per hour). | 17 km. (10.6 miles per hour). | 15 km. (9.3 miles per hour). |
| — 20 mm. (1 in 50) | 15 km. (9.3 miles per hour). | 14 km. (8.7 miles per hour). | 11 km. (6.9 miles per hour). |

Anticipated consumption on an easy section :

8 grammes of gas-oil per tonne-kilometre (7.4 drams per Engl. ton-mile) and 1 kgr. (2.2 lb.) oil per hour of run.

## Fiat rail motor coaches and locomotives.

The Fiat Co. of Turin (Italy) have built a 180-H. P. Diesel electric rail motor coach.

The general particulars are :

| | |
|---|---|
| Gauge | 1.445 m. (4 ft. 8 15/16 in.). |
| Length over buffers | 18.15 m. (59 ft. 6 9/32 in.). |
| Length over body | 17.20 m. (56 ft. 5 3/16 in.). |
| Width over body | 2.86 m. (9 ft. 4 19/32 in.). |
| Light weight on driving bogie | 12.6 t. (12.4 Engl. tons). |
| Light weight on carrying bogie | 9.4 t. (9.2 Engl. tons). |
| Weight of rail motor coach in working order | 44 t. (43.4 Engl. tons). |
| Maximum possible speed | 60 km. (37.3 miles) per hour. |
| Minimum track curvature | 80 m. (4 chains). |
| Number of seats | 38. |
| Number of standing places | 20. |

The compartments are heated by the cooling water of the Diesel engine. The rail coach is provided with the moderable automatic Westinghouse brake. In addition to the two driver's compartments, which are placed at each end, the body, constructed of wood and iron, includes a compartment reserved for the electric generating set and auxiliary appliances, a luggage compartment, a mail compartment, a 3rd class compartment, a vestibule with lavatory, and a 1st class compartment. Electric lighting is provided by a battery of accumulators, which is also used for auxiliary purposes.

The Diesel engine is a Fiat V 206 which has been specially designed for this coach and in which lightness and perfect balancing have received special consideration. It has 6 cylinders, 200 mm. (7 7/8 inches) diameter by 270 mm. (10 5/8 inches) stroke, working on the Diesel cycle with 4 strokes and airless injection of fuel. The normal capacity is 180 H. P., but the engine can maintain, without difficulty, an output of 200 H. P. The engine frame is made of cast steel and the cylinder liners of special cast iron. The cylinder heads are of cast steel, and each is provided with seatings for 2 air-inlet valves and 2 exhaust valves. The fuel inlet valve is in the centre of the cylinder head.

The engine shaft is made in one piece of nickel steel, and the connecting rods are of forged steel. The pistons are made in two parts; the lower part which carries the gudgeon pin, and serves to guide the piston in the cylinder, is made of aluminium alloy, while the upper part, which carries the piston rings, is made of rustless steel. Distribution is effected by a gear driven camshaft, valve rods, and levers acting on the valves which are made of rustless steel. The camshaft also possesses six cams which drive the pistons of the fuel pumps. The amount of fuel injected is regulated to the load by a governor. The fuel pumps are fitted with a small shaft driven by a compressed air servo-motor enabling the engine to be stopped from either of the two cabs. Forced lubrication of the engine shaft and connecting rods is ensured by a pump geared to the engine shaft. The centrifugal governor is mounted on the shaft, and maintains the speed of the engine constant.

The engine drives directly a main generator rotating at a constant speed. The energy furnished by this generator is transmitted to the two traction motors (one for each of the driving bogie axles) through the medium of a device of the Ward-Leonard type, which being very supple, gives a very wide range of speeds without the necessity of introducing resistances into the motor circuits.

The principal generator is a compound dynamo, which has one of its exciters separate, and which possesses the following characteristics :

85 kw., 750 revolutions per minute, 300 amperes, 360 volts.

The maximum excitation tension is 190 volts. The voltage of the main dynamo is varied by including resistances in the exciting circuit by means of a controller. This generator is also provided with a secondary winding so that it may be run as a series motor for starting the Diesel engine, the necessary power being supplied by a battery of alkaline accumulators.

The engine drives, by means of a belt and tightening device, a dynamo rated at 16 kw., 190 volts, and 2 000 revolutions per minute which feeds the separate excitation of the main generator and the auxiliary appliances of the Diesel engine, and charges up the battery. The voltage of this dynamo is regulated by an excitation rheostat.

Each of the two traction motors, rated at 54 kw., for 810 revolutions per minute, 400 volts, and 150 amperes, drives an axle of the driving bogie through the medium of a speed reducing gear (ratio : 21/74). These two motors are series wound and connected in parallel. An electro-pneumatically driven combinator reverse the motors by altering the direction of current in the armature. This electro-pneumatic control in turn is operated by a hand controller.

The following are the auxiliary sets :

1. The electrically driven water pump for circulating the cooling water through the Diesel engine. The pump is driven by a special electric motor to enable it to work while the engine is not running;

2. The fan set for the water cooler. These two sets are connected in parallel and they are started up by a reversing drum enabling them to be supplied with current either from the auxiliary dynamo or from the battery;

3. The air compressor providing the compressed air required for operating the brake. This set is controlled by a reverser and an electro-pneumatic contactor. The last-mentioned device ensures automatic starting and stopping of the set. According to the position of the reverser the set functions automatically or continuously. The consumption of the engine during test was 190 gr. (0.418 lb.) of crude oil per B. H. P. per hour.

The rail motor coach was tested in May, 1928, on the Trofarello-Chieri and Chivasso-Aosta line. It is now maintaining a regular service on the Firenze-Faenza line.

The Fiat Co., in view of the success achieved by this first example, designed :

a rail motor coach, 150 H. P., engine V 166,

a rail motor coach, 250-300 H. P., engine V 236,

a locomotive, 150 H. P., engine V 206,

a locomotive, 180 H. P., engine V 206,

a locomotive, 600 H. P., engine V 2312.

The particulars of the 600 H. P.-locomotive brake van, the most important of the units designed by the Fiat Co. are :

| | |
|---|---|
| Gauge . . . . . . . . . . . . . . . . . . . . . | 1.445 m. (4 ft. 8 7/8 in.). |
| Length of the body . . . . . . . . . . . . . . | 12.200 m. (40 ft. 11/32 in.). |
| Width of the body . . . . . . . . . . . . . . . | 3.050 m. (10 feet). |
| Length over buffers . . . . . . . . . . . . . . | 13.350 m. (43 ft. 9 19/32 in.). |
| Useful area of parcels van . . . . . . . . . . | 52 000 kgr. (146 400 lb.). |
| Total weight in working order . . . . . . . . . | 8 m$^2$ (86.1 sq. feet). |

The motor is an airless-injection Diesel engine with 12 cylinders, 230 mm. (9 1/16 inches) diameter by 310 mm. (12 3/16 inches) stroke, running at a speed of 800 revolutions per minute and developing 600 B. H. P. This locomotive is provided with the Westinghouse brake and two driving compartments.

It can draw the loads in metric (in English) tons shown in the following table (the weight of the locomotive being included) :

| SPEED. *Kilometres (miles) per hour.* | 15 (9.3) | 20 (12.4) | 30 (18.6) | 40 (24.8) | 60 (37.2) | 70 (43.5) |
|---|---|---|---|---|---|---|
| Level . . . . . . . . . | ... | 700 (689) | ... | 350 (344.5) | 230 (224.4) | 200 (196.8) |
| Gradient of 5 mm. (1 in 200) | ... | 430 (423.2) | ... | 215 (211.6) | 140 (137.8) | 120 (118.1) |
| — 10 mm. (1 in 100) | ... | 310 (305.1) | ... | 155 (152.5) | ... | 90 (88.6) |
| — 20 mm. (1 in 50) | ... | 200 (196.8) | ... | 100 (98.4) | 65 (64) | ... |
| — 40 mm. (1 in 25) | 155 (152.5) | 115 (113.2) | 75 (73.8) | ... | ... | ... |

## Rail motor coaches of the Pampelune-San Sebastian Railway (Spain).

These rail motor coaches built by William Beardmore & Co., of London and Glasgow, are 15 m. (49 ft. 2 1/2 in.) long and are mounted on two bogies of two axles each. The four axles are driving axles. The total weight of 29 t. (28.5 Engl. tons) is distributed as follows : 16.6 t. on the bogie on the engine side, and 12.4 t. on the other bogie. They are provided with two cabs and can run round curves of a radius of 25 m. (1 1/4 chains). Each motor coach can carry 32 seated passengers and pull two ordinary coaches each weighing 18 t. (17. 7 Engl. tons). Two motor coaches may be coupled up and driven by one man. The motor coaches are fitted with the vacuum brake and a screw brake. The vacuum is produced by a rotary air pump driven by the principal engine.

This principal engine is a Diesel engine with 6 four-stroke cycle, airless injection cylinders, 165 mm. (6 1/2 inches) diameter by 228 mm. (9 inches) stroke. It develops 220 B. H. P. at 1 200 revolutions per minute.

The generator is keyed to the crank shaft of the engine. It may be run temporarily as a motor to start the Diesel engine, the current being provided by an accumulator battery which also supplies current to the lighting circuit and the controlling gear. The armature shaft of the generator projects beyond the bearing, and to the overhung portion is keyed an auxiliary dynamo which serves as an exciter. The main generator is provided with a compound winding, such that the voltage automatically varies inversely with the strength of the current, the power thus remaining practically constant for any speed of the Diesel engine. The auxiliary generator, which is rated at 4 to 5 kw. and 75 volts, is so wound that its voltage is constant for a given speed, whatever the load. It provides the battery-charging current, the current for the exciting shunt of the main generator, for the lighting and for the controlling gear.

The four traction motors (one for each axle) can each develop 50 H. P. for an impressed voltage of 500 volts. They are suspended by springs and connected to the axles by gear wheels with a ratio of 70/14. These motors are connected in parallel.

Starting is gradual but rapid. The acceleration is 22 cm. (8 11/16 inches per second per second, that is 0.8 km. (0.5 mile) per hour per second up to a speed of 40 km. (25 miles) per hour which is attained in 50 seconds.

One motor coach is in use at the present time. The tests have satisfied the conditions imposed, and several units of the same type are being built.

## Ansaldo locomotives of the Italian State Railways.

This locomotive, built by the firm Ansaldo, S. A., of Genoa-Sampierdarena has just been put to the test on the Italian State Railways.

It is provided, in front, with a four-wheel carrying bogie, in the middle, with three coupled driving axles, and in the rear with one carrying axle.

The particulars are :

| | |
|---|---|
| Total length over buffers | 14.200 m. (46 ft. 7 in.). |
| Rigid wheel base | 10.200 m. (33 ft. 5 19/32 in.). |
| Fixed wheel base | 4.100 m. (13 ft. 5 7/16 in.). |
| Gauge | Standard. |

| | |
|---|---|
| Total light weight | 90 000 kgr. (198 416 lb.). |
| Total weight in working order | (94 000 kgr. (207 234 lb.). |
| Adhesive weight | 48 440 kgr. (106 792 lb.). |
| Diameter of driving wheels | 1.370 m. (4 ft. 6 in.). |

The engine is a horizontal six-cylinder Junker Diesel engine. The cycle is two-stroke, single acting. In each cylinder two pistons move in opposition with a stroke of 480 mm. (18 7/8 inches).

The diameter of the cylinder is 330 mm. (13 inches). The cylinders are of cast iron. Each piston is made of steel in one piece, with eight piston rings, and without direct cooling. The shaft is nickel steel and has six cranks, four of which are inside the frames, and two outside. The outside cranks drive the connecting rods which transmit the motion to the axles. There is, therefore, neither gearing nor speed reducer. The engine runs at speeds varying from 15 to 250 revolutions per minute. The valve gear is reversible and comprises two camshafts, one operating four cylinders, and the other two cylinders.

The fuel is injected by means of compressed air at a pressure of 50 to 70 atmospheres (735 to 1 030 lb. per sq. inch). The cylinders are scavenged by air at a pressure of 0.250 kgr. (3.55 lb. per sq. inch). The engine is started by means of compressed air. The power is regulated by varying the quantity of fuel, and the duration and pressure of the injection. The cylinders are cooled by the circulation of 2 500 litres (550 British gallons) of water cooled in air radiators. The temperature of the water reaches 80 to 100° C. (176 to 212° F.).

The normal power of the engine at the shaft is 700 H. P., and may be increased to 1 100 H. P.

The tests have just been started.

Loads of 300 tons to 500 tons can be pulled at 55 km. (34.2 miles) per hour over tracks of varying profile. The maximum power at the draw-bar hook was 450 H. P., the maximum effort 4 000 kgr. (8 818 lb.) while the fuel consumption was 6 to 10 grammes of Russian naphta of 10 900 calories (43 250 B. T. U.) per tonne-kilometre (5.44 to 9.23 drams per Engl. ton-mile) along the level.

### Locomotives of the Still or similar systems.

None of these locomotives is in use in the countries under consideration.

The Schneider Co. is the only firm engaged on this problem. They have had to quote for a locomotive to satisfy the following conditions laid down by the Tunisian Railways, *i. e.*, a locomotive to draw trains of 280 tons at an average speed of 65 to 70 km. (40.4 to 43.4 miles) per hour over lengths of track with no gradients greater than 6 mm. (1 in 167), maximum weight per axle 16 tons maximum wheel base 11 m. (36 ft. 1 in.), metre gauge. These conditions led to a machine of about 1 200 H. P. with 6 horizontal cylinders constituting three driving groups, two outside groups and one middle group, with cranks at 120°. Each pair of cylinders, arranged opposite each other, drives the upper arm of an equalizer, the lower arm of which drives the axle by means of a connecting rod.

The arrangements adopted by the Schneider Co. differ from the Kitson-Still locomotive on the following points : More direct drive to the wheels (there is no jack shaft);

Adoption of the two-stroke cycle in place of the four-stroke;

Certain improvements in detail have been provided with a view to improving the cooling of the pistons and to simplifying the operation of the locomotive.

### High pressure locomotives.

No locomotive of a pressure greater than 20 kgr. (284.5 lb. per sq. inch) is in use in the countries under consideration. The Paris,Lyons & Mediterranean Railway Company have just placed an order with the Henschel firm, of Cassel (Germany), for a locomotive working at 60 atmospheres (882 lb. per sq. inch) of the type described in the *Bulletin of the International Railway Congress* for May 1928.

The Nord Railway (France), on the other hand, have just been engaged in negotiations with the « Fabrique suisse de locomotives et de machines (Etablissements Angst) » of Winterthur, Switzerland, with the view of constructing a very powerful locomotive, based on the same principles as the trial locomotive built by that Company, and described in the *Bulletin of the International Railway Congress* for January 1929. The boiler working pressure will be 60 atmospheres (882 lb. per sq. inch).

### Locomotives not having boilers of the ordinary type.

On none of the railway systems of the five countries under consideration is there in existence any locomotives having boilers not of the ordinary type. Tests with water-tube boilers were carried out some time ago, but did not give satisfaction. They will be mentioned in order to refresh the memory.

In 1903, the Nord Railway Company (France) had built two 200-H. P. steam coaches with Turgan boilers (torpedo-boat type), with a working pressure of 16 kgr. (227.6 lb. per sq. inch). The trouble caused by the scaling of the tubes was such that the locomotives had to be stopped after running a short time. A Purrey boiler, working pressure 20 kgr. 284.5 lb. per sq. inch), was tried on one of them, but gave no better results. In 1906 these two steam coaches were fitted with locomotive type boilers of the same capacity (100 H. P.) with a working pressure of 12 kgr. (170.7 lb. per sq. inch) which gave every satisfaction. In 1908-1909 eight new steam vehicles were built with 250-H. P. locomotive type boilers with a working pressure of 12 kgr. (170.7 lb. per sq. inch). These 10 locomotives are still in service.

Despite these failures the design, begun in 1905, for an *Atlantic* engine (No. 2741) fitted with a cylindrical smoke-tube boiler, the fire-box walls of which, however, were formed of water tubes, was continued and the engine was built in 1906-1907. The troubles due to the deposit of scale in the tubes, and the unsatisfactory behaviour of the refractory bricks lining the fire-box, and the frequent and prolonged stoppages to repair the fire-box, were such that it was decided to transform this *Atlantic* engine into a *Ten-wheel* engine, which was done in 1913.

A boiler of the same type, with an ordinary cylindrical body, and a water-tube firebox was fitted in 1911 to a new *Baltic* engine (No. 3.1102). In 1913 this engine received an ordinary boiler.

This completed the trial of boilers with water-tube fireboxes on the French Nord Railway.

The Algerian System of the Paris, Lyons & Mediterranean Railway has also tried water-tube boilers. These boilers were constructed as follows. A large collector 950 mm. (3 ft. 1 3/8 in.) in diameter is arranged in the upper part along the entire length from the smoke-box to the back of the firebox and in the axis of the locomotive. A collector 500 mm. (1 ft. 7 11/16 in.) in diameter is arranged in the lower part in the axis of the locomotive from the smoke-box to the front of the firebox. These two collectors are connected by a 360-mm. (14 3/16-inch) pipe in the smoke-box and a 250-mm. (9 7/8-inch) pipe in the firebox, and between these two pipes, by a large number of water-tubes, over which sweep the hot gases. The back part of the upper collector forms the top of the firebox. The foundation ring of the firebox is hollow and forms a collector. The front, back, and side walls of the firebox are formed by tubes connecting the foundation ring to the upper header.

This boiler was fitted to engine 3003 and was put into service in February of 1904 (working pressure of boiler = 13 kgr. [185 lb. per sq. inch]) and in 1906 to the engines 3051 and 3055. After a few trials it was found that the grate area was insufficient, and in 1909, 1910, and 1911 new boilers were made, five for locomotives 3050 (type 4-6-0) and two for locomotives 4000 (type 0-8-0).

Very careful comparisons were made between these locomotives and locomotives of the same type but fitted with ordinary boilers. This was carried so far, even, as to change the drivers and stokers every month so as to eliminate the personal factor.

It was found that the locomotives with water-tube boilers consumed 10 to 20 % more fuel, than the ordinary locomotives; that the distance travelled was 81 % of that travelled by ordinary locomotives owing to stoppages for boiler repairs, that the cost of upkeep of the boilers (repairs to firebox, replacing tubes, washing, de-scaling, cleaning tubes) amounted to 241 % of the amount expended in the same work on ordinary boilers. There are no longer any of them in service.

The reason why the Algerian system tried water-tube boilers was to avoid the difficulties caused by the bad quality of the feed water, resulting in leaks and cracks in the stay-bolt heads and round the fire-tubes. On the Nord Railway, the trials were made for quite another reason. Mr. Koechlin, who was then chief engineer of the Locomotive works, was convinced that the efficiency of a locomotive would be increased by employing higher pressures, and without thinking at the time (1903 to 1905) of such pressures as 60, 100 and even 225 kgr. (853, 1 422 and 3 200 lb. per sq. inch) he anticipated a fairly high and proximate increase in the working pressure. His work on boilers with water-tube fireboxes was merely intended to test a device which he judged necessary for high pressures. Unfortunately, the tests came before their time, for nothing or very little was known about feed water heaters, in which a large part of the salts in the feed water are thrown down, and which perhaps would have minimized the disappointments sufficiently to enable the tests to be continued and the boilers to be brought to a state of perfection.

### General considerations.

On the whole, in the five countries under consideration : Belgium, Spain, France, Italy, Portugal, and their Colonies, there are no locomotives of new types in existence except a small number of Diesel locomotives and rail motor coaches. There are no turbine locomotives, no high-pressure locomotives, and no water-tube locomotives. This is obviously not very much on which to open a discussion regarding the locomotive of the future. Are we to say that the question has been raised too soon? In my opinion, no :

1. Because in other countries locomotives of the types in question are in normal service or the tests on them have been carried to a very advanced stage, enabling their future possibilities to be realized;

2. Because this question raised in an mission, hence the use of high-pressure to this new problem of the locomotive and to the different solutions which have been considered.

We should compliment and thank the President and members of the Permanent Commission of our Association for having set this question down on the Agenda of the Madrid Congress.

Ever since railways were first established, the general appearence of the locomotive has scarcely altered, the latent energy of the coal has always been used on the same principle. I do not mean by this that our predecessors in this field have not brought about considerable improvements; those improvements were intended to increase the tractive power and to effect a saving in fuel consumption (compounding, superheating, preheating of the feed water, progress in connexion with the exhaust, etc.). But, as a result of the conditions imposed by the railway operation, the steam locomotive has assumed proportions such that it is too cramped in the gauge limits imposed on it. On the other hand we are all of us convinced of the necessity, which is becoming more and more urgent, for cheap operation and consequently for considerable improvement in the efficiency of locomotives. We are inevitably at a turning point in the history of the locomotive and in the near future we shall have to make up our minds to strike out on absolutely new lines.

The question which at the moment is presented with most clearness, is that of increasing the power, notwithstanding the limitations of the gauge, and this especially in those countries where railways were first constructed. Other countries, where this method of locomotion was taken up later, have been able to anticipate the prodigious growth, and have had the wisdom to adopt less restrictive loading gauge dimensions.

This increase in power may be obtained in two ways :

1. By diminishing the exhaust pressure, hence the idea of the condenser, and

2. By increasing the pressure of admission, hence the use of high-pressures boilers.

The application of a condenser to locomotives with a reciprocating engine has never been anticipated, because it would necessitate, if the efficiency were to be satisfactory, the complete expansion of the steam down to the pressure of the condenser. This would lead to cylinders of enormous volume, and in a desire to gain space, more space would be lost. On the other hand, leakage at the slide valves, round the pistons, and at the glands would make it troublesome to maintain the vacuum. That is why the condenser implies the idea of the turbine.

The turbine involves a transmission of the motion. Up to the present all the designs provide for mechanical transmission, without speed variation or reversal. It is, in fact, the simplest form of transmission because it is effected by a series of toothed wheels. It is moreover the lightest, the least cumbersome, and the most efficient. But it has two serious drawbacks :

1. The necessity for a backward drive turbine which owing to lack of space is keyed on the same shaft as the forward drive turbine. Its working power, and efficiency therefore leave much to be desired;

2. The constant relationship between the speed of the turbine and that of the train.

Now the efficiency of a low-speed turbine is deplorable, as experience has shown. Locomotives with turbines arranged in this way give an efficiency greater than reciprocating engine locomotives only when the trains exceed a speed of 35 to 40 km. (22 to 25 miles) per hour. That is to say, the turbine locomotive in its present construction is only economical when drawing trains at high speeds with few stops, that is to say, for very special services.

The turbine might be imagined as using steam at much higher pressures that those at present customary in locomotives, but there is a relationship between the velocity of the steam entering the turbine, *i. e.* the pressure, and the peripheral speed of the turbine. An increase in the pressure of admission would lead to wheels of larger diameter which would probably no fit in with the restricted nature of the available space, or to rotary speeds necessitating too great a gear reduction. Moreover since the efficiency of the turbine is only satisfactory within limits fairly close to the normal speed, the efficiency at very low speeds would be still more deplorable with a high pressure of admission.

All these disadvantages would disappear if one could devise a transmission enabling the turbine to rotate at an almost constant speed. This transmission in fact does exist, it is the electric transmission, but in its present state, its weight and bulk are considerable and the efficiency is not so satisfactory as that of the mechanical transmission. On the other hand, it appears that it is less expensive to maintain.

Finally, the turbine locomotive is still in the stage of development. It is possible to imagine a locomotive with a high-pressure boiler, a main turbine suitable for this pressure, and running at a constant speed regulated by a governor. The power of the turbine would be transmitted to the axles by an electrical transmission, giving all the desirable suppleness suitable to the variation of the locomotive conditions, and permitting reversal of the direction of running. If we add a condenser, the whole evidently forms a complicated and cumbersome plant, but there is nothing to show that the progress which is being made step by step will not eventually lead to more suitable dimensions and weights. These various components possess the advantage of being fairly independent of each other, so that they can be arranged along the locomotive lengthways that is to say along a dimension which can still be increased without too much difficulty.

As for the high-pressure boiler, whether the steam is employed in a turbine or in a reciprocating engine, I believe that no one doubts it will be adopted fairly soon, on condition however, that it is a definite departure from the present type of boiler. If we desire to increase the power of locomotives within a loading gauge we shall not, in my opinion, solve the problem by adding a high-pressure element to the present boiler. This solution would merely complicate the apparatus and increase its dimensions. In adopting a higher pressure, we must try to reduce the encumbrance for a given power, or to increase the power for a given encumbrance.

As regards the saving of fuel, we know that the theoretical thermal efficiency increases with the pressure, but if, for a pressure of 15 kgr. (213.3 lb. per sq. inch) this efficiency is 18 %, it increases to 24 % for a pressure of 50 kgr. (710 lb.) and to 27 % for a pressure of 100 kgr. (1 420 lb.); hence there is a gain of 6 % between 15 and 50 kgr. and a gain of only 3 % between 50 kgr. and 100 kgr. The question which arises, therefore, is to determine to what pressure we should go, as a first stage, at least. The European firms who have attacked this problem have adopted the pressure of 60 atmospheres (882 lb. per sq. inch). I regard this as a wise precaution, because the difficulties to be surmounted are far from negligible. Besides, why go any further for the time being, the slight gain obtained by the theoretical thermal efficiency would be lost by the low efficiency of the engine which cannot, in the present state of affairs, make use of the full expansion of the steam. Restricted as to space, the locomotive builders are only considering, as regards high pressures, simple expansion (Winterthur) or a more or less restricted double expansion (Henschel), whereas in order to utilise fully the expansion either a triple-expansion would be necessary, or the high-pressure steam would have to be allowed to perform work in cylinders, followed by work at low-pressure in a turbine provided with a condenser. These solutions would obviously be very economical as regards fuel consumption but, apart from the difficulties of design and construction, would not the axle loads be far too great and would not the upkeep of such engines be too expensive?

Considerable advantages are presented by the application of the Diesel engine to locomotives : elimination of smoke and cinders, little noise if the engine is properly designed, no handling of coal and clinker; consumption of water considerably reduced; no necessity for ash pits; the engine is always ready, and consumes nothing when standing; the Diesel engine being capable of running without attention, it is possible, as on electric locomotives, to make daily runs of great length, and thus to reduce the number of locomotives in use. Compared with electric locomotives, the Diesel locomotive does not require power stations, sub-station, transmission lines, or current collectors, all of which are very expensive installations.

From the economical point of view, the Diesel electric locomotive has a thermal efficiency at the wheel tread of 22 to 25 %, while the present locomotive gives 5 to 9 % and the electric locomotive, if we include the power station, substations, transformers, and line losses, has a thermal efficiency at the tread of 10 to 12 %.

The Diesel engine possesses the disadvantage that it can only be started up light and is not self-starting. Its efficiency is only satisfactory for a power varying between very narrow limits. An overload may be disastrous. It is necessary to have, therefore, between the Diesel engine and the wheels, a transmission enabling the engine to be isolated, and allowing the train to travel at different speeds for the same engine speed, and as far as possible, the same engine power. The reversal of the direction may not necessarily be part of the transmission, for Diesel engines are built to run in both directions. This is, however, a complication which it would be best to avoid.

We thus return to the problem raised

in connexion with the turbine locomotive, but with this complication, that in addition to the simple transmission of the motion, a variable speed box and the possibility of completely declutching the engine are necessary. Moreover the mechanical transmission of a Diesel engine raises very difficult problems, and although there is in existence a 1 200-H. P. locomotive of this type, the builders do not readily undertake the construction of gears transmitting more than 400 to 500 H. P. For this reason the transmission is usually electrical. Even though the efficiency may be less satisfactory, there is the considerable advantage of the suppleness of this transmission and its low upkeep. The direct transmission of the Ansaldo Diesel engine is interesting in its simplicity, but the very slow speed of the engine must result in a considerable encumbrance and weight. The trials now in progress will provide us very soon with information on this point.

The question has been raised regarding the use of the two-stroke or the four-stroke cycle. The two-stroke cycle offers the advantage of a reduction in weight and in the constructional expenses, an advantage which is quite often of little importance, because scavenging necessitates a relatively slow piston speed, and requires the installation of a cumbersome and expensive scavenging pump absorbing about 6 % of the power of the engine. As regards the method of fuel injection. the airless injection method is adopted almost universally. This only requires a small oilpump which is simple and inexpensive, while compressed-air injection requires compressors, and coolers, and absorbs about 10 % of the power of the engine.

The Diesel engine, then, appears capable of being adapted for traction purposes, but it possesses another drawback which will probably become less serious as more progress is made in the construction of these engines. This is its weight. The first powerful Diesel electric locomotives (about 1 000 H. P.) weighed about 160 kgr. (353 lb.) per H. P. Recently 110 kgr. (242 lb.) has been attained, and some designs, not yet put into execution, it is true, provide for 90 kgr. (198 lb.). We must hope that soon 70 kgr. (155 lb.) per H. P. will be reached. Unfortunately liquid mineral fuel is not found everywhere in the world and transport appreciably increases its price. It is to be hoped that the Diesel engine builders will investigate the use of vegetable oils. This would be all the more interesting in view of the fact that the Diesel locomotive, in requiring only a small amount of water, would appear to be the ideal means of locomotion for Colonial railways in countries rich in oil-bearing plants.

## CONCLUSION.

In striving to attain maximum power, gauge limitations notwithstanding, and improved economic efficiency as regards traction, Railway Administrations are faced with a problem which is scarcely possible of solution except by the application of locomotives of a new type. This problem is of considerable importance, therefore, and the fact that it has been included in the Agenda of the Madrid Congress ought to direct the attention of those Administrations to the interest it possesses.

The question is by no means settled, and many years will pass before definite guiding principles can be formally adopted which, moreover, may vary with the requirements of local traffic, the gradients of the tracks, the climate, the amount and quality of water available, the price of the different kinds of fuel, training of the drivers and repairs staff, etc., etc.

Science progresses more and more rapidly, and the Railways, especially the Great Systems, cannot now lose interest in this progress, seeing that, ever since they have existed, they have been quick to apply new principles.

We have come to a parting of the ways, and it is difficult to know which is the right one. Shall we go on towards the turbine locomotive, the internal combustion engine, or the high-pressure boiler ? Great ability would be required to decide at present which line to take, because so few tests have yet been made, none having been made in the countries which have been allotted to me for the compilation of this report. My fellow reporters on the same subject have been more fortunate than I. They will give you fuller and more detailed information, the discussion of which will be more valuable.

I hope that, as a result of this Congress, many tests will be made of locomotives in which these new principles have been incorporated. But to make progress quickly, these tests must be methodical, and this can only be done in testing stations.

I should like to express a wish, therefore, that these testing stations, modern in every respect, should be installed in every country quickly, and that the details and the results of the experiments should be made known to all who are interested.

I am sure that the *Bulletin of the International Railway Congress Associations*, even now such an interesting publication, will willingly publish anything which may be communicated to it on this subject.

The question in this way would make rapid progress, which would make the reports and discussions at some future Congress particularly interesting.

[ 621 .134 ]

# REPORT No. 2

**(All countries except America, the British Empire, France, Italy, Portugal, Spain and their Colonies), China and Japan.**

## ON THE QUESTION OF IMPROVEMENTS IN THE STEAM LOCOMOTIVE (SUBJECT VI FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1) (2),

By THEODORE BALS,

ENGINEER, GENERAL SUPERINTENDENT, GENERAL MANAGER FOR WORKS AND ROLLING STOCK,
RUMANIAN STATE RAILWAYS.

Figs. 1 to 29, pp. 2426 to 2477.

The present report deals with improvements in reciprocating steam locomotives, within the limits fixed by the wording of Question VI, and only with steam locomotives the boilers of which — and in general the construction — are of the orthodox type, and therefore excludes locomotives of recent construction having high pressure boilers or locomotives fitted with water-tube boilers, these locomotives being dealt with in Question V.

In addition to the questions stipulated as having to form the subject of the present report, we have also briefly examined a few others, as for example, that of compounding, mainly with the object of stating some general indications on the present day state of development of these various questions.

We desire to state that amongst the Administrations covered by our inquiry, and who have been kind enough to send us some valuable information in reply, will also be found the Guillaume-Luxembourg Railway. This system is administered by the Alsace-Lorraine Railways, and consequently the information given for the above mentioned Railway is the same as that given by the Alsace-Lorraine Railways for their own system, and which will therefore be also found in the report relating to France.

## CHAPTER I.

### Increase in the boiler pressure.

*Boiler pressure adopted as a general rule since 1922, and the intentions of the Administrations.*

It is necessary to consider the cases of boilers for simple expansion locomotives and the boilers for compound locomotives separately.

The replies received from the different

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(1) This question runs as follows : « Improvements in the steam locomotive. Increased pressures and higher superheats. Improvements in the design of superheaters and parts connected with superheating. Feed water heating and air preheating. Improvements of valve gears. »

(2) Translated from the French.

Administrations show that, since 1922, the year of the Rome Congress, there has been no notable change as regards the boiler pressure adopted as a general rule, for both types of locomotives. For simple expansion locomotives, the pressure varies from 12 to 14 kgr. per cm$^2$ (170.7 lb. to 199.1 lb. per square inch), this latter figure appearing to become more and more general, especially for the powerful locomotives constructed during the last few years. Higher boiler pressures are only met with as exceptions; for example, the Rumanian State Railways possess 65 two-cylinder simple expansion locomotives, which were built in America, the boiler pressure of which is 15 kgr. per cm$^2$ (213.3 lb. per square inch) but it appears that these are a special case. For compound locomotives, pressures of 15 to 16 kgr. per cm$^2$ (213.3 lb. to 227.6 lb. per square inch) are the most general, and no Administration has reported any pressure higher than 227.6 lb. per square inch. It must, however, be observed that many of the Administrations consulted have not built any compound locomotives since 1922 (as in the cases of the Swiss Federal Railways, the Czecho-Slovakian State Railways, the Swedish State Railways, etc.), or else have no compound locomotives (as is the case with the Netherlands Railways).

Generally speaking, there has hitherto been no tendency to increase the boiler pressure,or else the Administrations having this intention in view have hitherto used lower boiler presures than those given above, and tend to adopt pressures approaching these. For example, the Norwegian Railways wish to increase their boiler pressure from 13 to 15 kgr. per cm$^2$ (184.9 lb. to 213.3 lb. per square inch) for compound locomotives, and the Bergslagen Railway (Sweden), from 12 to 14 kgr. (170.7 to 199.1 lb. per square inch). The motive for not raising the pressure of boilers of orthodox design is generally to be found in the increased maintenance charges which result from the increased pressure. For certain administrations the axle load on the rails, which are still limited to comparatively low figures by the permanent way, also plays a part, the raising of the boiler pressure involving thicker boiler plates, and therefore an increase in the weight of the boiler.

The Norwegian Railways alone advise us that they intend to build a locomotive with a boiler pressure of 17 kgr. (241.8 lb. per square inch) for trial purposes.

None of the Administrations consulted has therefore up to now carried out any trials with a view to increasing the pressure generally utilised, or to determine the influence of this increase on boiler maintenance, locomotives standing for repairs, and the expenses caused by these repairs.

## CHAPTER II.

## Superheating.

### A. — *Raising the degree of superheat.*

The primary object of our enquiry was to ascertain the temperatures of the superheated steam hitherto obtained, and at the same time to ask the Administrations in question what temperatures they would like to attain, and the reasons which had led them to select this temperature.

In general, apart from a few exceptions which are quoted further on, the temperature of the superheated steam in existing locomotives does not exceed 350° C. (662° F.), and the average for several administrations is rather lower.

Thus, on the Czecho-Slovakian Railways the temperature obtained is generally 330° C. (626° F.), and does not exceed this figure except for powerful locomotives, the efficiency of which is greater, on which a temperature as high as 355° C. (671° F.) is obtained. On the Polish State Railways, on the other hand the temperature of the superheated steam is maintained between 280 and 300° C. (536 and 572° F.) as on the Swedish State Railways. The Bergslagen Railway reports temperatures between 325 and 350° C. (617° and 662° F.) and the Danish State Railways between 350 and 400° C. (662 and 752° F.).

The Belgian National Railway Company possesses some types of locomotives constructed before 1914 which even with the original arrangement gave good results from the superheating point of view, giving about 325° C. (617° F.), when working heavily. Others, less good from the point of view we are dealing with, do not give a temperature exceeding 300° C (572° F.). On the other hand the locomotives which have been built during the last few years readily give 350° C. (662° F.) and some of these even reach 370° C. (698 F.) at high speeds (for example type 8 bis, present type 7).

As regards the temperature of the steam that the Administrations would like to reach, opinions are divided. The railways which to day have not used temperatures above 300° C. (572° F.) desire to go up to 350 or 360° C. (662 or 680° F.), without exceeding this figure which — in the opinion of many administrations — is sufficient from the point of view of fuel economy, and difficult to exceed because of the quality of the cylinder oils now used for lubricating pistons and valves. On the other hand, the Belgian National Railway Company considers 350° C. (662° F.) as a figure to be reached in normal working, whatever may be the pressure of the boiler, and would like to obtain at high speeds 370° C. (698° F.), without however going beyond this temperature, considering that a greater temperature might interfere with the lubrication of the components in contact with the superheated steam, without bringing about any appreciable increase in fuel economy.

The Bergslagen Railway intend to go up to 380° C. (716° F.) in a new type of freight engine they have at present under design. The Alsace-Lorraine Railways (as Administrators of the Guillaume Luxembourg Railway) would even like to raise the temperature from 380 to 400° C. (716 to 752° F.) in order to obtain the maximum economy which in their opinion is still compatible with efficient lubrication. We should mention here that the Swedish State Railways inform us that on the locomotives burning pulverised fuel, the temperature of the superheated steam rises as high as 450° C. (842° F.).

As regards *improving the superheat*, a few Administrations have supplied us with some very interesting information with regard to the data they use when designing superheaters for their new locomotives, and upon the trials they have made or have in hand.

Thus, the Belgian National Railway Company states that the method generally followed up to the last few years, for arriving at the dimensions for superheaters based on a certain ratio between superheater surface and evaporative heating surface, was erroneous (1). This method did not, in fact, take into consideration two important facts, viz. :

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(1) See also *Bulletin of the International Railway Congress Association*, August 1926, page 663.

*a*) The efficiency of the superheater surface diminishes more rapidly than that of the ordinary heating surface, as the length of the elements increases;

*b*) The distribution of the products of combustion between ordinary tubes and the superheater tubes plays an important part.

As a matter of fact, it had been noticed that, generally speaking, locomotives with long tubes, the ordinary tubes of which had a relatively large cross section, left most to be desired from the superheating point of view. Efforts were therefore made to improve it by increasing the free area of the large tubes containing the elements wherever the internal tubes were of large diameter, taking into account that a feed water heater was fitted which, in increasing the production of saturated steam per kilogramme of fuel demanded a more efficient superheater.

In the designs carried out, the standard dimensions for the large flue tubes have been taken as 125/133 mm. (4 29/32-5 1/4 inches) and for the superheater element tubes 30.5/38 mm. (1 3/16-1 1/2 inches). For boilers with long tubes and ordinary tubes of 50/55 mm. (1 31/32-2 3/16 inches) (instead of 45/50 mm. [1 49/64-1 31/32 inches]) flues of 128/137 mm. (5 3/64-5 25/64 inches) diameter, or even 131/140 mm. (5 5/32-5 1/2 inches) diameter, have been used at the same time keeping the diameter of the superheater elements at 30.5/38 mm. (1 3/16-1 1/2 inches). Similarly the rule has been not to bring the return bend of the superheater elements close back to the smokebox tubeplate for all lengths of tubes, but to make the distance between the return bend at the smokebox end and the spear end at the firebox end 3 m. (9 ft. 10 1/8 in.).

Alterations on the above lines were made to the type 10 locomotives, constructed in 1910, and which with the original superheater arrangement only gave a superheated steam temperature of less than 300° C. (572° F.). The number of superheater elements has been increased from 31 to 40, and the number of ordinary tubes reduced from 230 to 190. The large tubes have a diameter of 128/133 instead of 118/127 mm. (5 3/64-5 1/4 inches instead of 4 5/8-5 inches), the superheater elements 30.5/38 instead of 27/34 mm. (1 3/16-1 1/2 inches instead of 1 1/16-1 3/8 inches), and the ordinary tubes have been kept at 45/50 mm. (1 49/64-1 31/32 inches) diameter. The distance of the spear ends from the firebox tubeplate has been maintained at 610 mm. (24 inches) [it is, however, intended to reduce this distance to 520 mm. (20 1/2 inches) in order to still further increase the superheat]. As a result of these modifications, steam at 350°-355° C. (662°-671° F.) is now readily obtained. We should add that the dampers were dispensed with when making the alterations.

The *Bergslagen Railway* has also carried out some work of interest in regard to the improvement of superheating. Taking as a starting point the principle that in order to construct a boiler with the Schmidt type of superheater with large tubes, or to improve the superheating of existing boilers of this type, it is necessary to be able to calculate as accurately as possible the relative resistance to the flow of gases in the large and small tubes respectively. Messrs. Nordling and Bengtzon undertook a series of tests on the resistance offered by the tubes to the passage of the gases and have devised a method of calculating this resistance.

This method was published in *Glasers Annalen* Nos. 1153, 1154, and 1155 of 1925.

Moreover, in order to increase the superheat, Messrs. Nordling & Bengtzon have arranged, instead of the plain tubes, tubes called « Ess » tubes, the walls of which are pressed so that they present on the inside three spirals running the whole length of the tube, and leaving between them hollow spiral passages which impart a rotary motion to the gases (fig. 1). This results in a very close contact between the gases and the tube walls, resulting in an increase in the heat transmitted, as has been ascertained from the decrease in temperature of the gases in the smoke-boxes of saturated steam boilers fitted with these tubes.

The effect of the « Ess » tubes used instead of ordinary tubes on superheated locomotives is that as the resistance to the passage of the gases by these tubes is greater, a greater proportion of the gases passes through the large superheater tubes, and the superheat is thereby increased. Should this effect be too accentuated, it can be diminished by employing spiral superheater elements, the presence of which in the large tubes has an effect similar to that produced by the « Ess » tubes (fig. 2).

The use of the « Ess » tubes and the methods of calculating the resistance to the passage of the gases indicated above, have given satisfactory results to the Bergslagen Company. The experience of the Norwegian State Railways confirms the efficiency of the « Ess » tubes. On this Administration, the boilers of superheated locomotives have a superheater surface ranging between 28 and 30 % of the total heating surface, and the superheater temperature reached is 300°-350° C. (572°-662° F.) according to the rate of working. By simply substituting « Ess » tubes for plain tubes of small diameter, and without any other modification to the boiler, the superheater temperature was increased by 30° C. and even by 50° C. (50° and 90° F.).

We believe it will be of interest to give below a few figures with regard to the results obtained with the « Ess » tubes. In consequence of the satisfactory tests carried out by the Bergslagen Railway on stationary locomotive type boilers, this Company, put in hand some comparative tests on two six-coupled saturated steam locomotives, one of which was fitted with ordinary plain tubes, and the other with « Ess » tubes, both working the same service, under conditions as identical as possible. The average results of these tests were as follows :

| | Locomotive with « ESS » tubes. | Locomotive with plain tubes. |
|---|---|---|
| Temperature in smoke box . . . . . . . . . . . . | 210° C. (410° F.) | 332° C. (630° F.) |
| Temperature of water in boiler. . . . . . . . . . . | 178° C. (352° F.) | 177° C. (351° F.) |
| Difference in temperature between products of combustion and the water in the boiler . . . . . . . . . . . | 32° C. (58° F.) | 155° C. (280° F). |
| Evaporation per pound of coal . . . . . . . . . . . | 8.26 lb. | 6.73 lb. |
| Economy in coal for the locomotive fitted with « ESS » tubes. | 18.5 % | ... |

The Guillaume-Luxembourg Railway (Alsace-Lorraine Railways) also considers that the dimensions of the superheaters must be determined by considerations of the resistance of the tubes to the passage of the gases, and gives as the formula to be applied :

$$\frac{S}{Q} = \frac{s}{q}$$

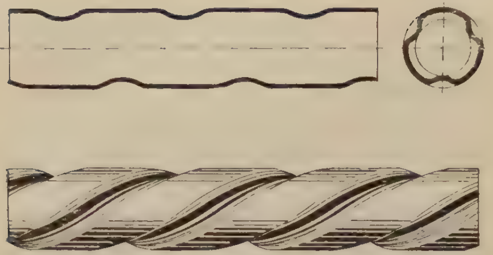


Fig. 1. — Ess tubes (Bergslagen Railway).

where

- S is the frictional surface of the large tubes;
- Q the free area of the large tubes;
- *s* the friction surface of the small tubes;
- *q* the free area of the small tubes.

The Swiss Federal Railways, in order to direct at will a larger proportion of the flow of gases from the firebox through the large superheater tubes, have fitted their locomotives of the type A 3/5 with a movable plate, placed in the smokebox and capable of pivoting round a horizontal axis in such a manner as to cover more or less (even completely) the ends of the ordinary evaporative tubes. The position of this cover can be regulated from the driver's cab by means of a rod fitted with a pointer which moves over a graduated scale.

The *Polish State Railways* have at present in hand trials with baffle plates designed by Mr. Madeyski, the object of which is to direct a larger volume of the gases through the superheater tubes. The trials carried out up to now promise an increase in the temperature of the superheated steam of at least 50° C. (90° F.) [the temperature at present obtained does not exceed 300° C. (572° F.) as has been indicated above]. However, the type of partition in question has not yet been definitely decided on, and it is for this

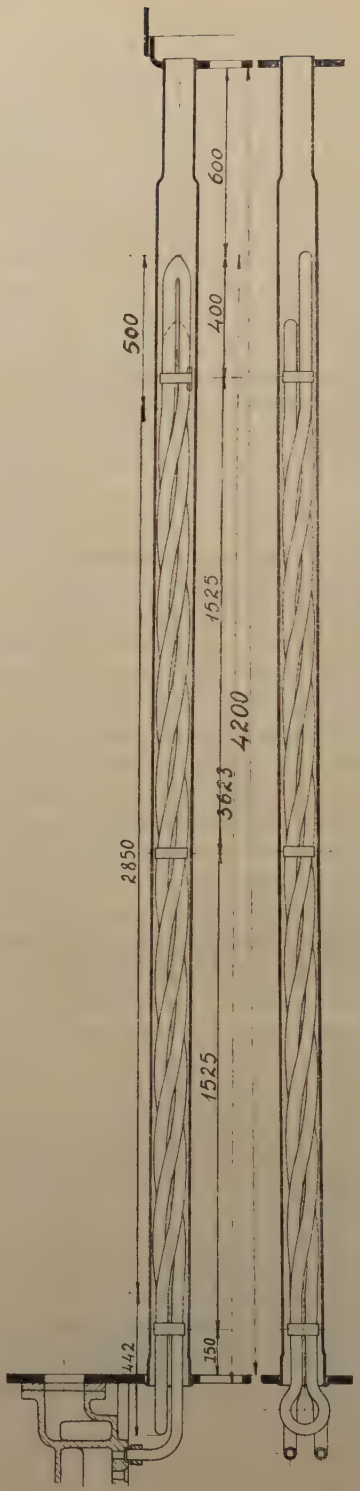


Fig. 2. — Spiral superheater elements.

reason that the Polish Administration has refrained from forwarding up to the present any drawings of these partitions.

To sum up, it appears that the majority of the administrations are aiming at an increase in the degree of superheat, and at the same time are exercising prudence on account of the difficulties of lubricating the parts in contact with the superheated steam, which appears to limit the temperature to 370° C. (698° F.) (even for compound locomotives with a boiler pressure 16 kgr. (227.6 lb. per square inch), a temperature which is moreover high enough to ensure a satisfactory fuel economy. Figures higher than 700° F. are only indicated as being desirable in exceptional cases. The usual dimensions of the large tubes are 125/133 mm. (4 29/32-5 1/4 inches) (which are also, it seems, the lower limit), and are increased with advantage to 128/137 mm.(5 3/64-5 25/64 inches) or even 131/141 mm. (5 5/32-5 9/16 inches) by the Belgian National Railway Company if the length of the tubes exceeds 4.50 to 5 m. (14 ft. 9 in. to 16 ft. 5 in.)

The proportion of 5.5 smoke tubes of 45/50 mm. (1 49/64-5 1/4 inches) diameter per superheater element (large tubes of 125/133 mm. [4 29/32-5 1/4 inches]) seems suitable. With a coal consumption of 500 kgr. per m² (102 lb. per square foot) of grate area per hour, the proportion of gases which passes through the superheater is sufficient to give temperatures of 350° C. (662° F.). The longer the tubes, the more should the ratio of the number of tubes to the number of elements be reduced, and inversely if the tubes have a length less than 4.500 m. (14 ft. 9 in.) (Belgian National Railways).

As regards the *best arrangements for headers* from the point of view of increasing the degree of superheat, it seems that, in general, the usual arrangement of the Schmidt system gives satisfaction and is used by the large majority of the Administrations consulted. The Belgian National Railway Company has however fitted on its locomotives of recent construction two other types of headers, *viz.*:

1. The Superheater Company's header; and

2. The « Belgian » header.

The first is practically the same as the Schmidt, whilst the second has a series of small vertical headers, placed side by side, one half distributing the saturated steam to the superheater elements, and the others receiving the superheated steam, connected to two main horizontal headers, the former in communication with the steam supply pipe in the dome, and the latter connected to the main steam pipes to the cylinders (fig. 3).

The two steam chambers are thus completely separated, any transmission of heat or of leakage between them being thus completely avoided; the superheater elements no longer require to be bent at their ends connected with the header.

These two types moreover give equal satisfaction in service.

In order to arrive at certain conclusions from the results obtained as regards the improvement in superheating by Administrations, we have made a résumé, in the *table of Appendix I*, of the most interesting data supplied, and have tried to bring into special relief the influence of the following ratios on the temperature of superheat obtained :

$$\frac{\Sigma}{C} = \frac{\text{Superheater surface.}}{\text{Total heating surface.}}$$

$$\frac{S_S}{S_B} = \frac{\text{Total free area through the superheater tubes.}}{\text{Total free area through the evaporative tubes.}}$$

(both measured in the centre portion of the tubes, and without taking into account the superheater element supports).

$$\frac{R_S}{R_B} = \frac{\text{Resistance to the passage of gases of the superheater flues.}}{\text{Resistance to the passage of gases of the evaporative tubes.}}$$

$$\frac{N_B}{N_S} = \frac{\text{Number of ordinary tubes.}}{\text{Number of superheater flues.}}$$

It is particularly interesting to consider these ratios in relation to the locomotives which have been modified to improve their superheating, by comparing them with the same locomotives not modified. This is the case with the types 10 and 36 locomotives of the Belgian National Railway Company, and types F and S*a* locomotives of the Swedish State. It appears to result from an examination of this table that satisfactory results (temperature of 325° C. [617° F.] and above) are obtained, in the case of the Schmidt superheater with large tubes, if the above-mentioned ratios have approximately the following values :

$$\frac{\Sigma}{C} \geqslant 0.33 ; \quad \frac{S_S}{S_B} \geqslant 0.75 ; \quad \frac{R_S}{R_B} \leqslant 0\ 35$$

The ratio $\frac{N_B}{N_S}$ is less expressive in itself, the respective dimensions of the tubes of course playing an important part. With the usual dimensions, a ratio of 4.75 to 5.50 seems to be satisfactory.

The formulæ which were used for calculating the resistances to the passage of the gases are indicated in the table, Appendix I, in question.

For the *Schmidt superheaters with small tubes* [70/76 mm.(2 3/4-3 inches)], in which the majority of the tubes are occupied by superheater elements of « U » shape, the ratios are obviously quite different.

We find that on recently constructed locomotives of the Czecho-Slovakian State Railways which give on the average a steam temperature of 325° C. (617° F.), these ratios (although ranging between wide limits) have the following average values :

$$\frac{\Sigma}{C} = 0.35 \text{ to } 0.45 ; \quad \frac{S_S}{S_B} = 4.5 \text{ to } 5.5 ;$$

$$\frac{R_S}{R_B} = 0.4 \text{ to } 0.6 ; \quad \frac{N_B}{N_S} = 0.22 \text{ to } 0.42.$$

### B. — *Best arrangements for superheaters and fittings connected with the application of superheating.*

In what follows, we will examine what are the best arrangements to be adopted in order to obtain as good a performance in service as possible, simpler construction or a greater facility for maintaining the superheaters, piston valves and accessory parts met with on superheated steam locomotives.

### 1. — Superheater.

#### a) *Types of superheaters chosen by the different administrations and reasons for choice.*

Almost all the administrations consulted state their preference for superheaters with large tubes, generally of 125/133 mm. (4 29/32-5 1/4 inches) diameter; the majority of them have adopted the

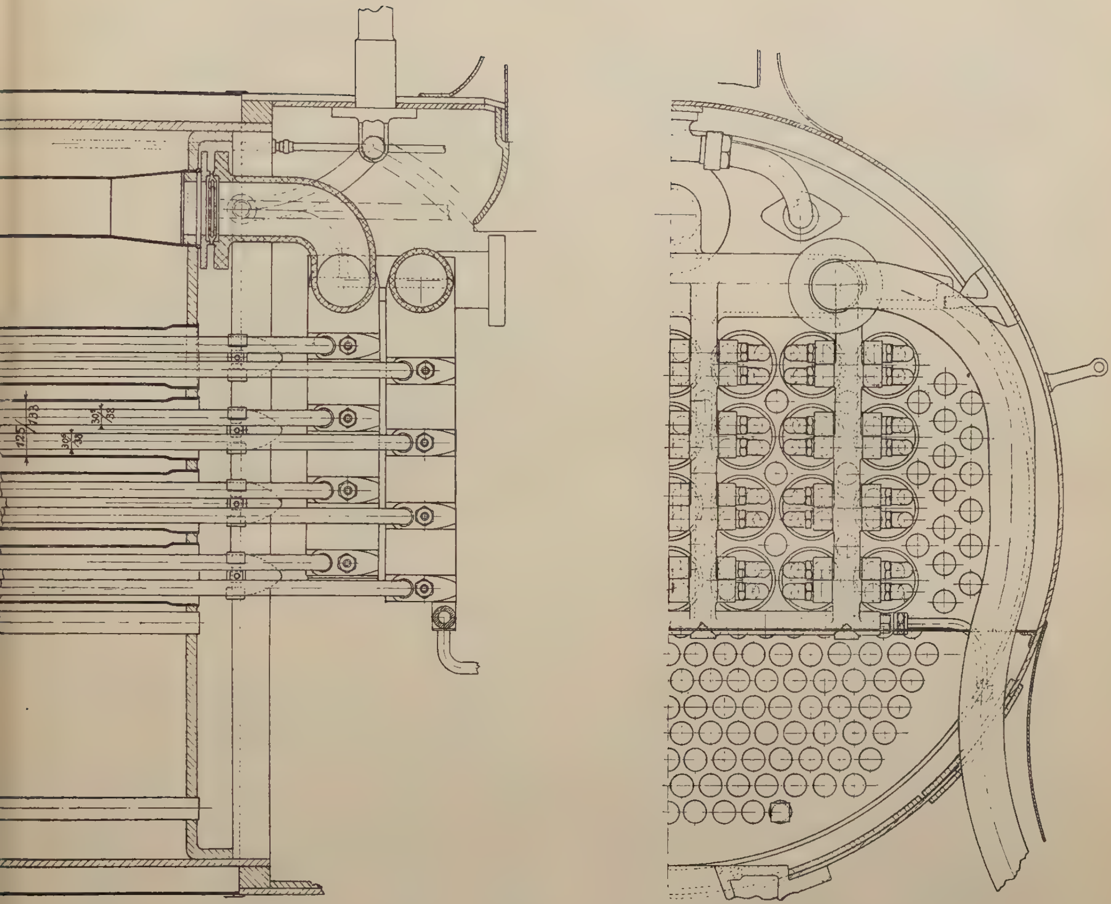


Fig. 3. — « Belgian » superheater.

Schmidt type. The reasons stated to justify this choice are, in general, that the superheater with large tubes is simpler, that it causes less loss of pressure the superheater elements being greater in diameter, that there is less blocking up than with elements placed in small tubes, the cleaning of the tubes being very much easier than with this latter system.

However, the Czecho-Slovakian State Railways have, on the contrary, adopted, for their locomotives of recent construction and for those which have been rebuilt, the Schmidt superheater with elements placed in tubes of small diameter, 70/76 mm. (2 3/4-3 inches), with elements of 19/24 mm. (3/4-15/16 inches) diameter.

This choice was made for the increase in the total evaporating surface, as well as of the superheating surface obtainable with this arrangement, and this administration does not make any difficulty in cleaning the tubes as a result of using this type of superheater.

The Rumanian State Railways also pos-

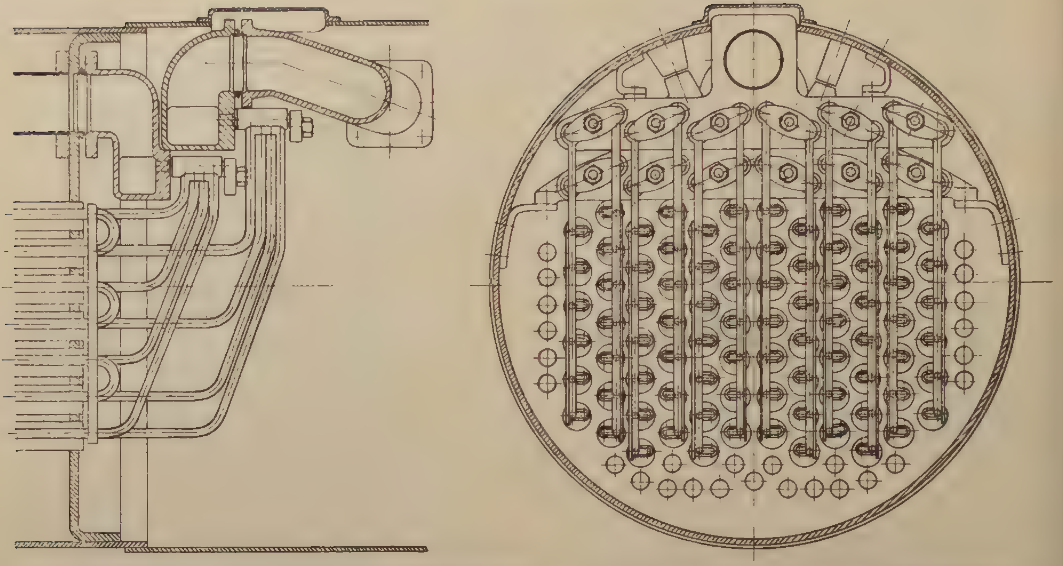


Fig. 4. — Schmidt superheater with small tubes (70/76 mm. = 2 3/4—3 inches). (Rumanian State Railways.)
(*See continuation of this figure on opposite page*).

sess a number of tank engines of the 2-6-2 and 2-8-2 type, fitted with Schmidt superheaters with small diameter tubes (70/76 mm. = 2 3/4-3 inches), (elements 19/24 mm. = 3/4-15/16 inches), the performance of which is satisfactory. Figure 4 shews the general arrangement of the superheaters of these locomotives. This type of superheater has the advantage that the normal degree of superheat given by the locomotive is obtained much more rapidly after the opening of the regulator than with the superheater with large tubes, the quantity of steam to be superheated being divided into a larger number of streams of smaller diameter. It appears, however, that this type of superheater necessitates the use of coal of good quality, to prevent the tubes from blocking up.

The Netherlands Railways also employ the small tube superheater, but only for their smallest locomotives.

b) *Types of spear ends adopted for superheater elements. Minimum distance from the firebox tubeplate.*

The majority of the administrations covered by our inquiry use, with good results, spear ends fixed to the element tubes by autogeneous welding. The spear ends are generally made of cast steel. The Czecho-Slovakian Railways use elements rolled in one single piece with their spear ends, on the Mannesmann system, whilst the Guillaume-Luxembourg Railway (Alsace-Lorraine Railways) use forged Schmidt spear ends without welding or with caps welded on the tubes at 250 mm. (9 37/32 inches).

The use of spear ends welded to the tubes, or else forming one single piece with these latter, is widely adopted because of the less resistance they offer to the flow of the gases on the one hand, and to that of the steam on the other.

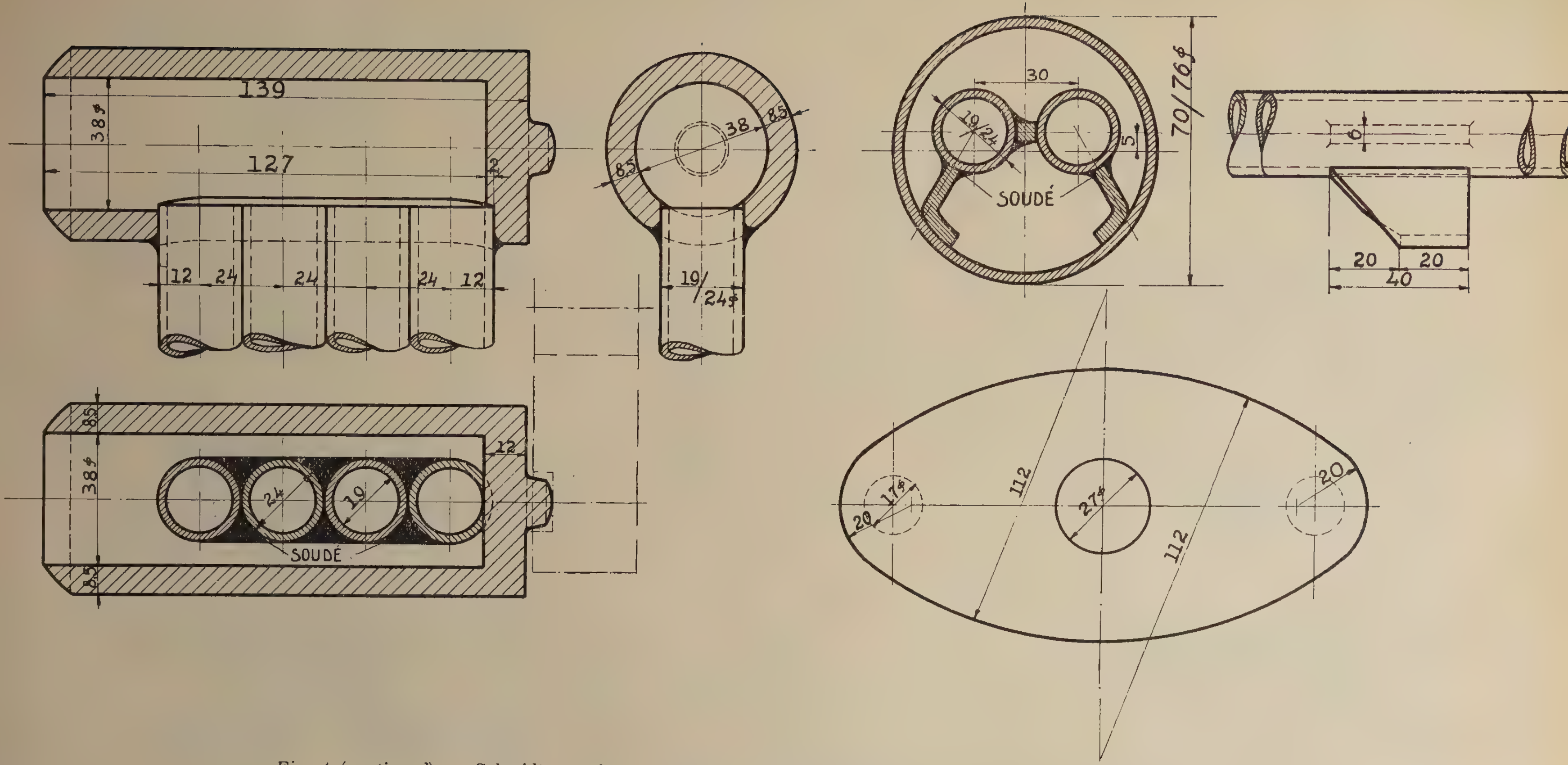
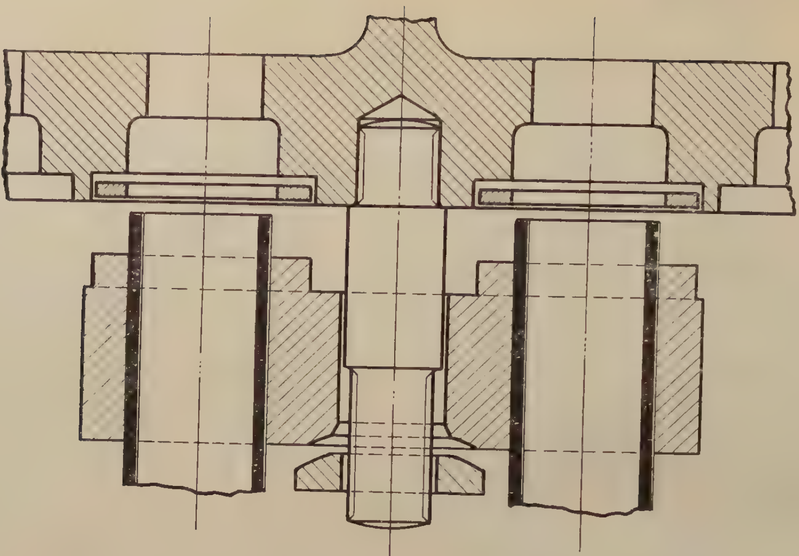
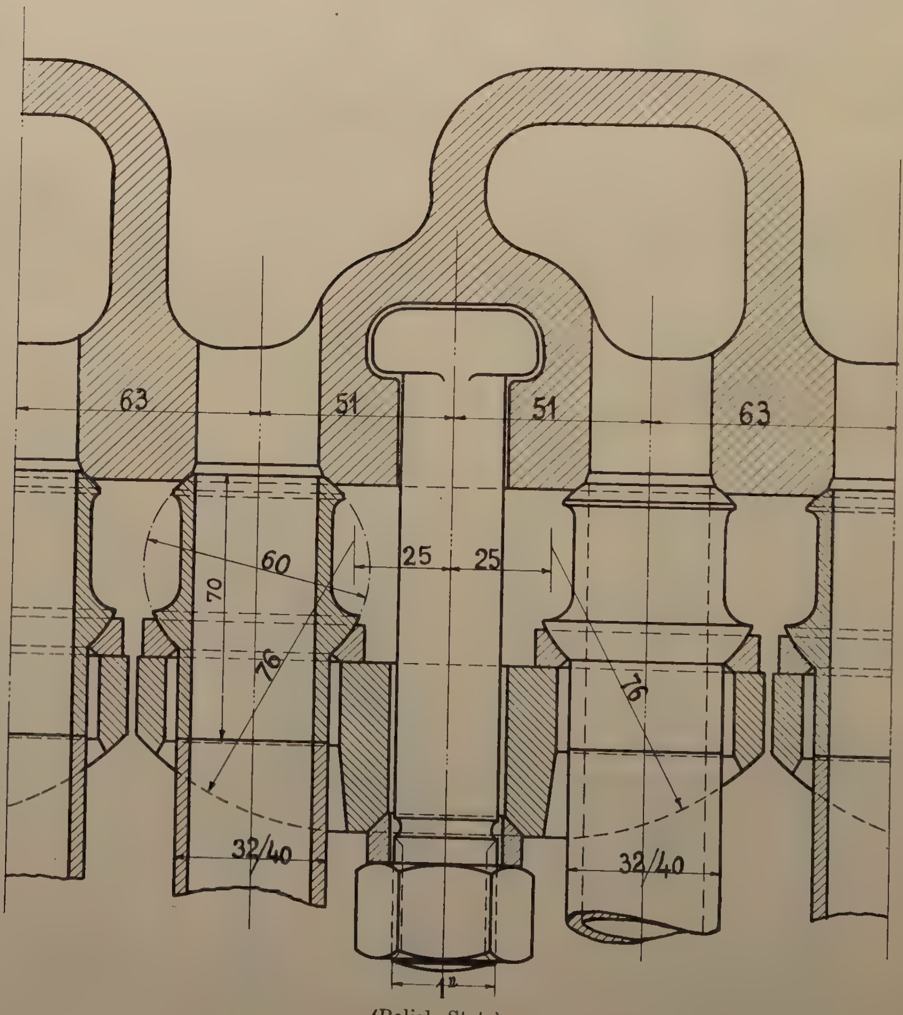


Fig. 4 (*continued*). — Schmidt superheater with small tubes (70/76 mm. = 2 3/4—3 inches). (Rumanian State Railways.)

Fig. 5. — Details of methods o

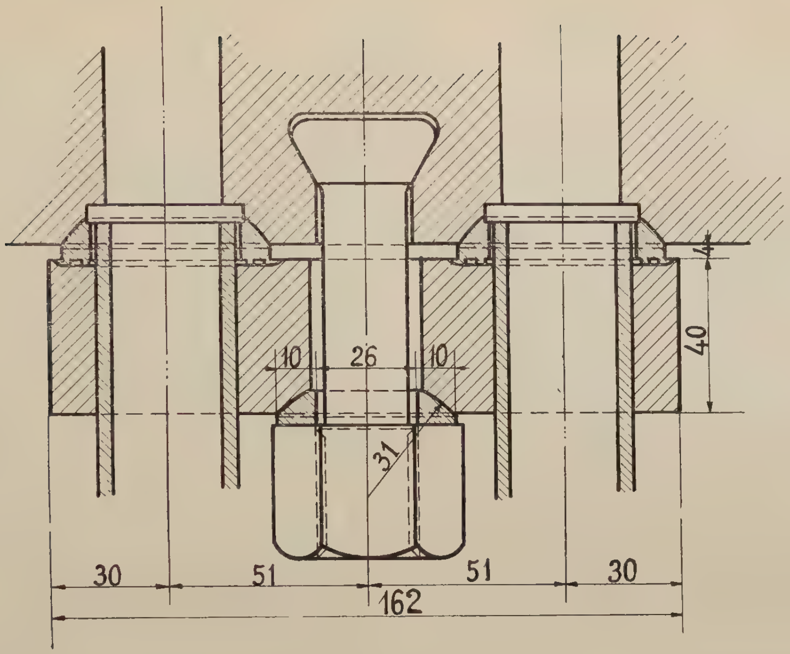


Guillaume-Luxembourg (Alsace-Lorraine).



(Polish State).

erheater elements on headers.



(Swedish State).

As regards the distance between the spear end and the tubeplate, this varies in general between 500 and 610 mm. (19 11/16 and 24 inches). However, shorter distances are met with, for example, 350 mm. (13 3/4 inches) on the Prince-Henry Railways and Mines; the Czecho-Slovakian Railways have adopted the figure of 400 mm. (15 3/4 inches) for their new locomotives, whilst the Bergslagen Railway go as far as 700 mm. (27 1/2 inches).

c) *Arrangements adopted for securing the ends of the superheater elements to the headers.*

With superheaters with large flues, the assembling is generally done by clamping the ends of the superheater elements, which are provided with a conical seat, and grouped in pairs in a block for screwing up against the corresponding openings in the header.

The Polish State Railways, whilst retaining this system, have two seatings on the ends of the elements, one fitting over the hole in the header, and the other receiving the thrust from the block through an intermediate piece, with the object of equalising the pressures on the ends applied against the header.

The Swedish State interposes jointing washers between the block and the seatings in the header.

The other administrations generally use, to ensure steam tightness, soft metal joints, usually made of a flanged copper ring containing inside an asbestos washer, which are simple and efficient. The Netherlands Railways employ the Goetze type washers for the same purpose.

Figure 5 shews a few of the arrangements above.

For superheaters with small tubes, the assembling is carried out by means of junction boxes, into which the four elements ends are welded (see fig. 4).

### d) *Superheater dampers.*

Apart from the Rumanian and the Bulgarian State Railways, no other administration amongst those consulted, now uses dampers on superheaters, without any trouble having arisen through burning of the elements when the regulator is closed. On many of the administrations no modifications have been made to the locomotives, in consequence of the removal of the dampers, whilst other administrations (Czecho-Slovakian State, Polish State, Belgian National Railways, Bergslagen Railway) have fitted large air valves on the saturated side of the header, which come into operation when the regulator is closed, and by admitting air to the cylinders, prevent the burning of the elements.

On the Belgian National Railways, this air valve is operated by compressed air which, at the same time, operates the by-pass valves of the cylinders. It comprises, moreover, an injection of live steam operated by the driver, which increases the activity of the air circulation in the superheater, and helps to preserve the lubricating oil in the cylinder. The cock operating the injection of live steam is kept open as long as the locomotive is running whether the regulator be open or closed. (For further details see *Bulletin of the Railway Congress*, August 1926, page 663.)

### 2. Pyrometers for superheated steam.

The majority of the administrations do not consider it necessary to have a pyrometer on every superheated locomotive. A few like the Guillaume-Luxembourg do not fit any on their locomotives, whilst others like the Polish State only maintain them on their passenger locomotives. The Bulgarian State Railways, however, fit these instruments on all their superheated locomotives.

Pyrometers are at present used rather for superheater test purposes than for everyday working, the conditions of temperature of the steam produced being now sufficiently well known.

The instruments employed by the administrations who make use of them (if only for tests) are rather varied. Many of them use thermo-electric pyrometers of the Siemens-Halske type (Czecho-Slovakian State, Swiss Rederal Railways, Rumanian State, Norwegian State, Bergslagen Railway, Netherlands Railways, Danish State, Finnish State) or the Steinle and Hartung with the « 0 » position fixed (Norwegian State and Swedish State, in the last few years).

Others prefer the Steinle and Hartung or Fournier saturated steam tension pyrometers (Belgian National Railway Company, Danish State and Norwegian State), or else those with a tube of mercury placed in the header, also made by Steinle and Hartung (Swiss, Bergslagen).

All these instruments are, we believe, too well known for us to give a description of them.

The replies received to the question as to whether the instruments do or do not give satisfaction give rather different opinions. It however seems clear from the replies received that these are delicate instruments, which frequently get out of order, and generally have a short life. The repairs they require are frequent, and indicate that they ought to be improved to enable them to be adopted for the rough service demanded of instruments used on locomotives.

However, the Swiss Federal consider the mercury instruments the strongest, but having the defect that their indications cannot be easily read by reason of their position.

The Belgian National Railway Company prefer the Fournier pyrometer (saturated steam tension) as giving the safest indications and being sufficiently sensitive, whilst the preferences of the Norwegian Railways are for the Steinle and Hartung pyrometer with the « 0 » position fixed.

The Swedish State shares this opinion.

In general, even if pyrometers are not fitted on locomotives, arrangements are made to enable a test pyrometer to be easily added. The Guillaume-Luxembourg Railway is the exception with regard to this point.

### 3. — Lubrication of pistons and valves.

#### a) *Superheater oils used.*

The table, appendix II, shews the characteristics of the oils used by the different administrations who have sent in their specifications.

In addition to the data shewn in this table, the Belgian National Railway Comny gives the following information on this subject :

The proportion of matter soluble in boiling benzol contained in the matter precipitated by the petroleum ether in use in the Malines laboratory (density at 15° C. [59° F.] ranging between 0.645 and 0.650 and distilling in the Engler de Somer and Runge apparatus between 30° C. and 70° C. [86° and 158° F.]) must not exceed more than 0.5 % of the oil tested. This test is carried out by using for the precipitate 60 cm² of petroleum ether per gramme of oil to be tested (6.5 cubic inches per dram). When submitted to fractional distillation by means of superheated steam, in the apparatus in use in the Malines laboratory, the oil must not distil more than 30 % of its volume at the temperature of 300° C. (572° F.) and 60 % of its volume at the temperature of 350° C. (662° F.).

The oil will not be definitely accepted until after a practical test of a type 36 locomotive hauling freight trains on a given line. The test distance will be about 2 000 km. (1 240 miles).

From the point of the satisfaction given by the oils bought in accordance with these specifications, the Belgian National Railway Company state they are satisfied with them for the superheat obtained in everyday service in which the steam has a temperature of 340° to 350° C. (644° to 662° F.).

The following Railways are also satisfied : the Swiss Federal Railways, the Swedish (the temperature of the superheated steam generally does not exceed 300° C. (572° F.) on these locomotives), the Czecho-Slovakian State (for temperatures up to 330° C. (626° F.), considering the difference of 20° to 40° C. (36° to 72° F.) between the flash point and the temperature of the steam at admission as sufficient), the Polish State as regards American oil, and the Bergslagen Railway.

The Polish Railways are not, on the other hand, entirely satisfied with the home-produced oils they use. Efforts have been made to overcome the lubricating difficulties resulting from their use, on the one hand by improving their quality, and on the other hand by using special lubricating devices, as for example mechanical lubricators with atomisers. The results obtained up to the present give rise to the hope that it will be possible to use native oil on all their locomotives.

The oils used by the Danish Railways also fail to give satisfaction at high degrees of superheat.

The Norwegian Railways, in turn, are not satisfied with the oils supplied in accordance with the conditions shewn in the table, appendix II, as they gradually carbonise up the valves. They have had under trial for some time some well filtered oils, having a lower flash point than that shewn, and notably : 295° C. (563° F.) in an open vessel and 260° C. (500° F.) in a closed vessel (Pensky-Martens apparatus). In view of the short time which has elapsed since the commencement of the trials of these oils, no opinion can be expressed on this subject yet.

The Guillaume-Luxembourg Railway (Alsace-Lorraine Railways) in turn are not entirely satisfied with the oils used, and they are at present carrying out some comparative tests with oils from different sources, on the results of which will depend the modifications to be made in their specifications for the supply of superheater oil.

To the question as to whether trials have been made with a view to ascertaining the relations existing between each of the characteristics of the oils and their lubricating power, the majority of the administrations have replied to us in the negative. It is generally considered that practical trials in service are the only means capable of enabling the quality of the oils to be judged, the laboratory trials only serving to determining the technical characteristics of the oils.

### b) *Types of lubricators adopted.*

In general, the administrations consulted prefer mechanical lubricators for their superheated locomotives. However, the Belgian National Railway Company also use displacement lubricators, and consider them the equivalent of mechanical lubricators. The Alsace-Lorraine Railways also use them on the Guillaume-Luxembourg concurrently with mechanical lubricators, whilst the Norwegian Railways fit them on their locomotives simply as a standby for the mechanical lubricators.

The types of lubricators used by the various administrations are summarized below :

| ADMINISTRATION. | Types of lubricators. | |
|---|---|---|
| | Displacement. | Mechanical. |
| Belgian National Railway Company. | Detroit. | Zeyen, Bourdon, Wakefield. |
| Swiss Federal Railway . . . . . | ... | Friedmann. |
| Czecho-Slovakian State . . . . . | ... | Friedmann with Friedmann atomiser. |
| Polish State . . . . . . . . . . | ... | Friedmann. |
| Norwegian State . . . . . . . . | Nathan. | Friedmann, Bosch. |
| S. H. S. State (Kingdom of the Serbs, Croats and Slovenians). | ... | Friedmann, Michalk. |

| ADMINISTRATION. | Types of lubricators. | |
|---|---|---|
| | Displacement. | Mechanical. |
| Swedish State | ... | Friedmann (with atomiser at present under trial), Dicker and Werneburg, Bosch, Wakefield. |
| Bergslagen Railway | ... | Friedmann with Friedmann atomiser, class B. |
| Netherlands Railways | ... | Friedmann, Wakefield, Michalk. |
| Finnish State | ... | Friedmann. |
| Guillaume-Luxembourg Railway | On old locomotives. | Michalk, Dicker & Werneburg. |
| Rumanian State | ... | Friedmann, Michalk, Bosch. |
| Bulgarian State | ... | Friedmann. |
| Prince Henry | ... | Friedmann. |
| Danish State | ... | Friedmann, Wakefield. |

All the types of lubricators enumerated above are well known, and need no description. We will, however, briefly describe the *oil atomisers*, the use of which seems likely to develop in view of the good results which have been obtained up to the present.

The only fault in mechanical lubricators is the fact that the oil they deliver to the cylinders and steam chests arrives there in the form of drops, which fact favours the formation of deposits of oil which are easily incrusted and choke up the piston rings and piston valve rings.

The function of the atomising apparatus, which is mounted as near as possible to the delivery ends of the lubricating pipes in the steam chests and cylinders, above these latter, is to ensure, by means of a jet of steam, the distribution of oil over the whole of the wearing surface, in a similar manner to a displacement lubricator.

Figure 6 shews the details of construction of the Friedmann type of apparatus. The steam, as dry as possible, arrives at B, passes through the ball valves D, and meets in the space R the oil arriving under pressure from the mechanical lubricator through E, the ball valve L and the pipe F. The steam carries the oil through the atomising pipe N towards the point to be lubricated.

All the administrations state they are satisfied with the apparatus they use, and which were selected either after comparative trials carried out, or as having shown themselves to be satisfactory in practice. The oil pumps (Friedmann, Bosch, types, etc.) seem to enjoy special preference, because of the possibility they afford of regulating and controlling the quantity of oil supplied by each oil pipe, at the point where it is used.

The *back pressure valves for the mechanical lubricators* are generally supplied by the same manufacturers as the lubricators employed. In the atomisers described above, the back pressure valve forms part of this fitting. The Norwe-

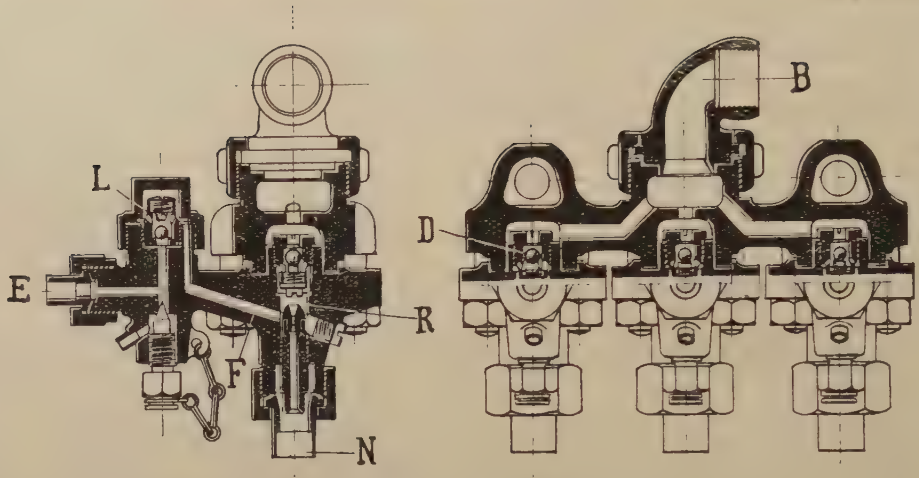


Fig. 6. — Oil atomiser, Friedmann type.

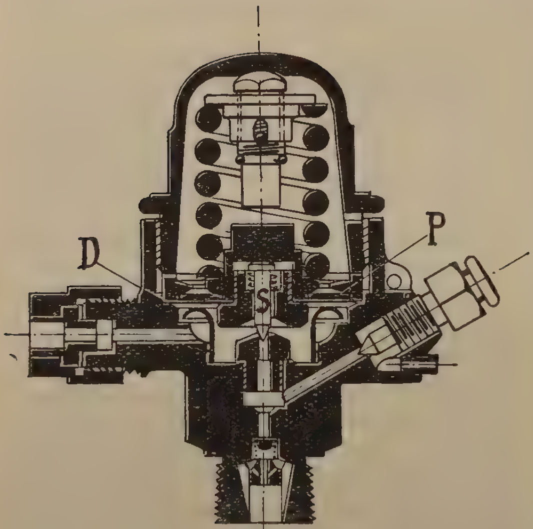


Fig. 7. — « Olva » back pressure valve (Friedmann).

gian State is at present trying some back pressure valves of the Michalk type, whilst the Guillaume-Luxembourg (Alsace-Lorraine), although satisfied with the back pressure valves they have in use, propose to carry out some comparative trials between these and the capillary tube with strainer of the Bernard and Poncet type, as used by the French Est Railway Company.

The Czecho-Slovakian State Railways have put in hand the trial of some «Olva» type back pressure valves, with diaphragm (fig. 7), which, by reason of its freedom from leakage, seems capable of preventing the oil pipe from being emptied when the counter-pressure of the steam ceases, and therefore gives promises on the one hand of economy in oil, and on the other hand, of certainty of always having the lubrication ensured from the first turn of the wheels.

The « Olva » valve consists of a needle-valve S (instead of a cone or ball valve employed hitherto), pressed on its seat by a spring, so that it cannot be lifted by a pressure of steam acting on the needle. The oil, under pressure from the pump, acts, on the contrary on the large diaphragm D, which is fitted with a supporting plate P. The spring is set so that the valve lifts at a pressure of 2 to 3 kgr. (28.4 to 42.6 lb. per sq. inch) above the working steam pressure.

Generally, for a boiler pressure of 14 to 16 kgr. per cm$^2$ (199.1 to 227.6 lb. per sq. inch) the pressure of the oil in the oil pipe reaches about 18 kg. per cm$^2$ (256 lb. per sq. inch).

The Prince-Henri Railway also employs these « Olva » valves.

For their displacement lubricators, the Alsace-Lorraine Railways (Guillaume-Luxembourg) employ double-seated valves of the « Detroit » type, with chokes 2 mm. (5/64 inch) diameter, and placed near the points to be lubricated.

### c) *Number of lubricator feeds and positions of outlets.*

The practice generally followed by the administrations we are dealing with is to have (for piston valves) two lubricator feeds per piston valve and one feed per cylinder. In addition, the lubricators are generally employed for lubricating the piston rods (at least in the H. P. cylinders), which gives 8 feeds per lubricator.

Often, on modern locomotives, the mechanical lubricators are used also for lubricating the crosshead guides, axleboxes, the bearing surfaces of the bogie, firebox supports, etc., which results in the number of feeds necessary being rather large. In such cases, several mechanical lubricators are mounted on the locomotive, the maximum number of feeds per lubricator being 8 to 10. Figure 8 shews, as an example, the diagrammatic representation of the lubrication, by two mechanical lubricators, with atomisers, of a recent three-cylinder locomotive, series 386.0 (4-6-2 type) belonging to the Czecho-Slovakian State.

Certain administrations do not carry the oil to the piston valve liners (hence two feeds per piston valve), but lead a single oil tube into the steam supply pipe, just before it enters the steam chest, by means of an oil diffuser (see fig. 9). The results are generally good, and the number of feeds is thereby reduced. For example, on the Guillaume-Luxembourg Railway (Alsace-Lorraine) they employ :

For the H. P. piston valves : one feed per valve;

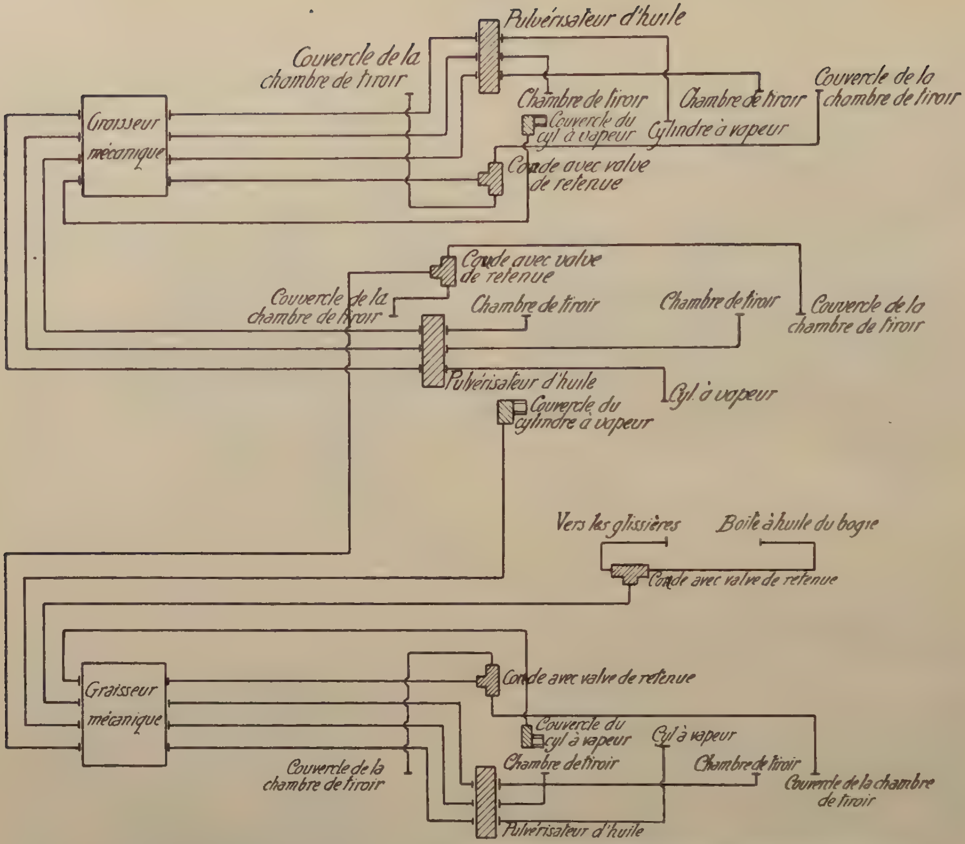
For the H. P. cylinders : one feed per cylinder;

For the L. P. piston valves : one feed per valve.

### d) *Use of lubricants other than oil.*

Several administrations have under trial the use of lubricants other than oil. Thus, the Czecho-Slovakian State Railways are trying oil emulsions : Vapóroil, Panoil, Ostra, both on saturated and superheated locomotives. These emulsions are mixtures of good mineral oils with 42.6 % to 48 % of water, some of these also containing about 2 % mutton fat which increases the emulsive capacity. The density of these emulsions varies between 0.948 to 0.979, the viscosity at 50° C. (122° F.) is 86.2 to 182 degrees (Engler) and the total alkalinity 0.10 % to 0.18 %, the grease content 1.6 % to 1.9 %, and the ash content 0.10 % to 0.35 %.

These emulsions do not decompose below 40° C. (104° F.). Between 40° and 60° C. (104° F.) they are no longer stable, and above 60° C. they decompose and water appears in considerable quantities. If the emulsion congeals and its heated up it does not lose its stability. An important point is that the emulsion must not come into contact with the steam before it arrives at the point it is to lubricate, for fear of causing it to decompose. It is therefore essential that the back pressure valves shall be quite free from leakage. On the other hand, care must be



Pulvérisateur d'huile
Couvercle de la chambre de tiroir
Graisseur mécanique
Chambre de tiroir
Chambre de tiroir
Couvercle de la chambre de tiroir
Couvercle du cyl à vapeur
Cylindre à vapeur
Coude avec valve de retenue
Coude avec valve de retenue
Couvercle de la chambre de tiroir
Chambre de tiroir
Chambre de tiroir
Couvercle de la chambre de tiroir
Pulvérisateur d'huile
Cyl à vapeur
Couvercle du cylindre à vapeur
Vers les glissières
Boîte à huile du bogie
Coude avec valve de retenue
Graisseur mécanique
Coude avec valve de retenue
Couvercle du cyl à vapeur
Cyl à vapeur
Couvercle de la chambre de tiroir
Chambre de tiroir
Chambre de tiroir
Couvercle de la chambre de tiroir
Pulvérisateur d'huile

Fig. 8. — Arrangement of mechanical lubrification on 4-6-2 locomotive (Czechoslovakian State.)

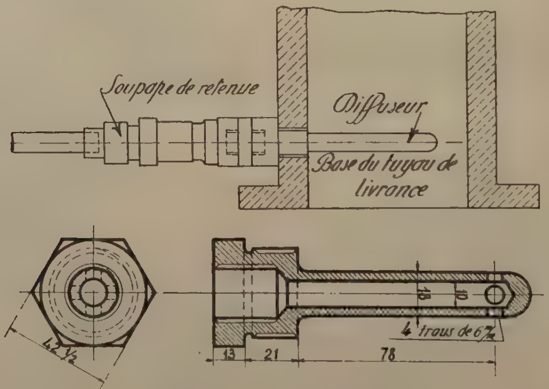


Fig. 9. — Oil atomiser.
(Belgian National Railway Company.)

*Explanation of French terms in figs. 8 and 9*: Base du tuyau de livrance = End of steam pipe. — Boite à huile du bogie = Bogie axlebox. — Chambre de tiroir = Piston valve liner. — Coude avec valve de retenue = Back pressure valve. — Couvercle de la chambre de tiroir = Steam chest cover. — Couvercle du cyl. à vapeur = Cylinder cover. — Cylindre à vapeur = Cylinder. — Diffuseur = Spoon end. — Soupape de retenue = Back pressure valve. — Vers les glissières = To slide bars. — 4 trous de 6 m/m = 4 holes 6-mm. (15/64 inch) diameter. — Graisseur mécanique = Mechanical lubricator. — Pulvérisateur d'huile = Atomiser.

taken that the temperature of the emulsion in the mechanical lubricator does not exceed 40° C. (104° F.) because otherwise, as we have just said, water appears and produces all kinds of troubles, particularly in frosty weather.

The great advantage of these emulsions is that they do not produce any carbonisation and it even seems that the emulsion dissolves that produced by the usual superheater oils. As regards the results given by the emulsions from the point of view of wear of the parts lubricated, the consumption of lubricant, and the fuel consumption, it may be stated there is hardly any difference compared with the use of oil.

The prices of the emulsions used are, on the other hand, only about 82 % to 85 % of those paid for oils used in Czecho-Slovakia. The trials are being continued with a view to making the emulsions more suitable. It should be added that the lubricators have not been altered in any way by reason of the use of the emulsions.

The *Polish State* Railways have also in hand some trials with an emulsion of grease oils, with water added. For their use, the lubricator atomiser, patented by the Polish Engineer Wordliczka, is being tried on a large scale, and is giving very satisfactory results.

On the Swedish State Railways, they are partly using a mixture of colloidal graphite with the oil. The lubricators are used as they were before, and this mixture is giving good results used with the Friedmann oil atomisers.

In Belgium the use of emulsified oil is being looked into.

In conclusion, in Norway the lubricating oil is partly mixed with « Oildag » (finely pulverized artificial graphite mixed with mineral oil).

### 4. — Piston valves.

We requested the various administrations to state whether, since 1922, they had made any modifications in the design of piston valves for steam distribution.

It seems clear from the replies that such is not the case. The use of piston valves with narrow piston valve rings, 6 to 7 mm. (1/4 to 9/32 inch) wide, the number and thickness of which depend on the diameter of the piston valve, has become general, and those administrations which possess older locomotives having piston valves with wide rings have altered these latter by fitting them with narrow rings. However on the Belgian locomotives, type 10, rings 16 mm. (5/8 inch) wide are met with, and on the Swiss locomotives, rings 25 mm. (1 inch) wide.

The only point that might be stressed in the question of valves is the fact that the Swedish State Railways inform us that in converting their saturated locomotives to superheated locomotives, the flat valves have generally been retained. These flat valves are usually made of bronze containing 86 % copper and 14 % phosphor-tin (with 5 % phosphor). It is to be noted, however, that on these administrations the temperature of the superheated steam generally does not exceed 280° to 300° C. (536° F. to 572° F.), as we have already stated.

The Prince-Henry Railway follows the same practice.

We must moreover, recall that at the Rome Congress in 1922, the possibility of retaining the flat valves, even unbalanced, when superheating is applied to a saturated steam locomotive, had already been reported. In Switzerland and England, no difficulty was experienced in following this practice, especially if care was taken to fit on the engine at the same time a mechanical lubricator to introduce oil under pressure under the flat valve. The fact is also reported that flat valves made of bronze give better results, under these conditions, than those made of cast iron.

### 5. — Packings for valve rods and pistons.

#### a) *Types adopted or tried.*

It may be said that all the superheated steam locomotives, on the railways dealt with in this report, are fitted with metallic packings. One of the oldest, and still in widespread use, is the standard Schmidt which is met with in large numbers in Sweden, Norway, Czecho-Slovakia, Rumania, Holland, on the Guillaume-Luxembourg Railway, etc.

However, many administrations have tried or even adopted other types of metallic packings.

Thus, the Czecho-Slovakian Railways are replacing the Schmidt packing with a packing of the *Huhn* or *Hauber* type on existing locomotives, which latter packings they also use for their locomotives of recent construction. The Huhn type, with rings of special cast iron, is used by these administrations for their powerful locomotives working fast and stopping trains, whilst the Hauber packing is fitted only on their powerful freight engines.

Figures 10 and 11 shew these packings.

The Rumanian State Railways and those of the Danish State have also introduced, for trial purposes for the time being, the Huhn packings, whilst the Hauber type packings are now also being adopted by the Polish State Railways and those of the S. H. S. Kingdom (¹).

On the Belgian National Railways the type of packing preferred is the « Crescent », with which 150 2-8-0 locomotives (type 38) were fitted when they were built. This packing is shewn in figure 12, and includes alloy rings containing 80 % lead and 20 % antimony, fusible at 360° C. (680° F.).

On the Swiss Federal Railways the valve spindles often pass through a long liner, and are fitted with a series of annular grooves, so as to form a labyrinth packing. The rings contain 89 % tin, 7 % antimony, and 4 % copper.

In Norway, Schmidt packings are also used, but the packings for the valve spindles have recently been dispended with and replaced by a labyrinth packing as in Switzerland.

Trials have also been made during the last few years with different types of packings, notably :

Movable *Pacific* spring packings, made by « Spezialfabrik für bewegliche Federpackungen »;

*Huhn* cast iron packings;

A modification of the *King* packing (see fig. 13), the rings of which are made of an alloy containing 85 % lead and 15 % antimony.

The Netherlands Railways are also using, for their piston rods, packings of the *Sack & Kiesselbach* type, which have also been used, with success, by the Prince-Henry Railway, and for trial purposes by the Danish State.

The Alsace-Lorraine Railways have several types of packings under trial on their locomotives using a very high degree of superheat, *viz.:*

*a*) Modification of the alloy of the rings (60 % lead and 40 % copper instead of 80 % lead and 20 % antimony used in the Schmidt packings);

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(¹) Abbreviation often used to designate the Kingdom of the Serbs, Croates and Slovenians.

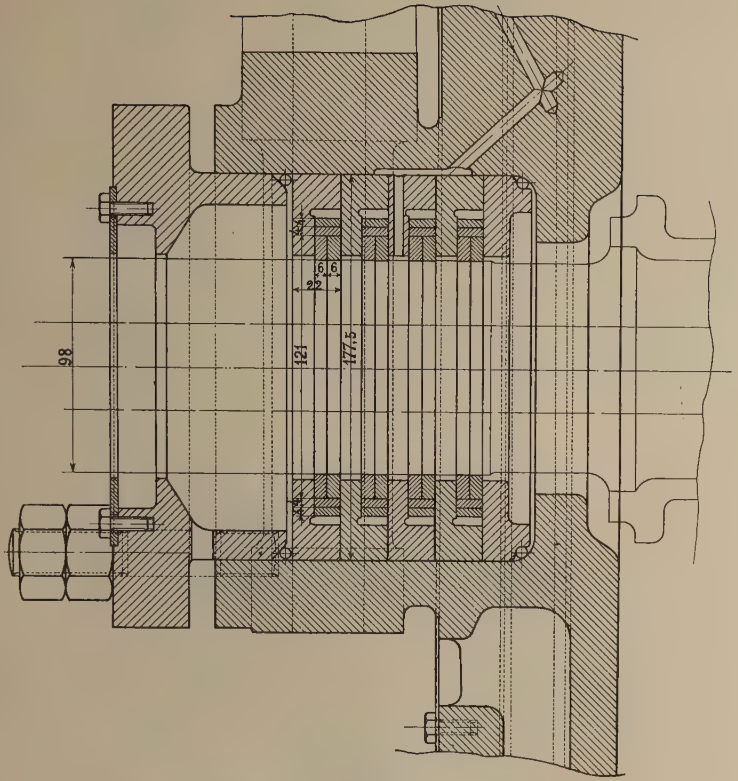

Fig. 10. — Hauber type packing.

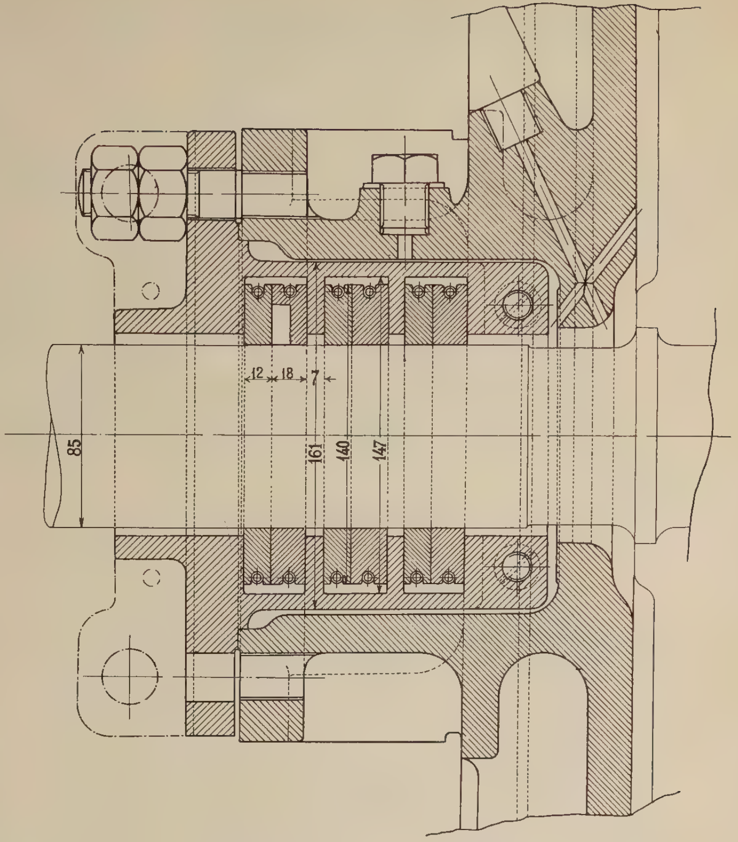

Fig. 11. — Huhn type packing.

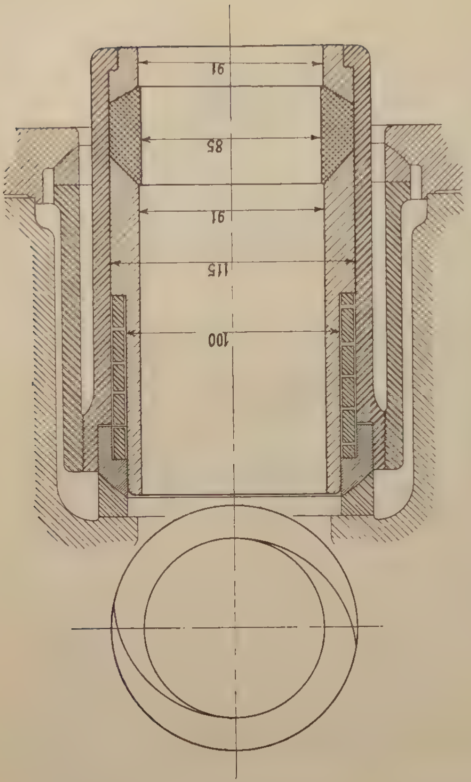

Fig. 13. — Modified King packing (Norwegian State Railways).

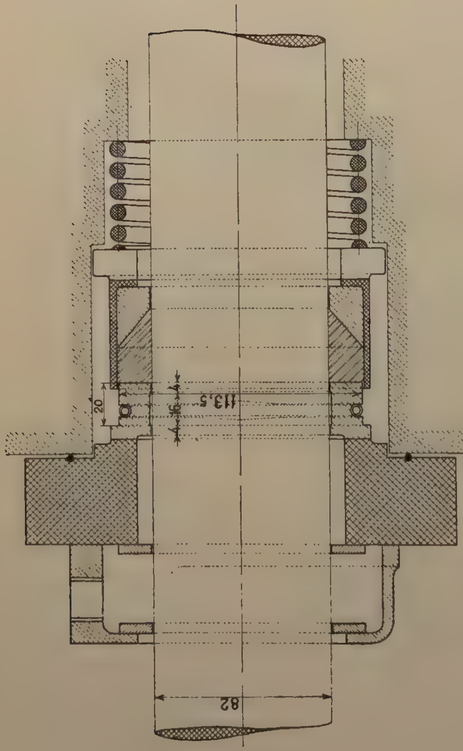

Fig. 12. — Crescent packing (Belgian National Railway Comp'ny).

*b*) Huhn packings, Hauber packings, and Garex packings. (The Garex packings are simply noted here, as they have already been abandoned).

On the Swedish State, it is to be noted that when the old saturated locomotives were converted into superheated, the original type of packing was retained (fixed gland with white metal rings). The packing rings for superheated locomotives, Schmidt type, contain 65 % lead, 20 % tin and 15 % antimony, this composition being also adopted by the Bergslagen Railway.

The different metallic packings which have just been mentioned are used, in general, for the piston rod (for the H. P. cylinders only in the case of compounds), and for the valve spindles in the case of outside admission. For inside admission, the fit of the spindle in the bush is sufficient.

The lubrication of the packings is generally carried out with superheater oil, very often by means of mechanical lubricators. The oil is introduced, for the packings of the Huhn or Hauber types, between the rings.

As regards *performance in service* of the different types tried and adopted, the Czecho-Slovakian Railways have furnished us with some useful information. The Huhn and Hauber packings used by them give satisfaction in service, their maintenance is easy and cheap. They remain in service for at least six months, *i. e.*, between two piston and valve examinations, during which time the locomotive has run between 36 000 and 42 000 km. (22 400 and 26 100 miles). By way of information, it should be mentioned that the distance run between the periods when the locomotives are lifted and stripped (*i. e.*, every two years) is reckoned in Czecho-

Slovakia for locomotives hauling fast trains and passenger trains, at 144 000 to 168 000 km. (89 500 to 104 000 miles).

For the purpose of repairing any possible damage to these packings, the Huhn type is particularly advantageous, in view of the fact that all the rings can be taken out at once by withdrawing the common box which contains them.

It is to be noticed that the Huhn and Hauber packings necessitate the rod being guided, because they are only intended to ensure steam tightness. From the point of view of price, the Schmidt packing is cheaper, but its maintenance costs are appreciably higher. Its life amounts, in general, to six months, but during this time replace rings have to be fitted, and other maintenance work carried out, which has led the Czecho-Slovakian Railways to decide to standardise the use of the Huhn and Hauber packings.

As regards the Schmidt packings with rings made of alloy containing 80 % lead and 20 % antimony (A. P. 3 alloy), the Alsace-Lorraine Railways (Guillaume-Luxembourg) state that this alloy is not suitable for high degrees of superheat, because it begins to melt towards 360° C. (680° F.).

The opinion of the Norwegian Railways is that the modified King packings give satisfactory results.

Apart from the Czecho-Slovakian Railways, other administrations reserve their decisions as to the type to be standardised in the future, the period of trial not generally being considered as concluded.

### 6. — Relief valves. — Air valves. By-pass valves.

Consulted as to the need for these fittings, the administrations have not, in general, carried out any special trials or observations, since 1922, with this object in view, but it appears that all of them consider these fittings to be necessary in order to ensure free running of the locomotive when the regulator is closed; the locomotives recently built are fitted with them.

*The air valves, or snifting valves,* which were originally placed at the bottom of the cylinders, or on the steam supply pipes, are now often fitted on the saturated steam space of the header, as we have already shewn with regard to the removal of the superheater dampers (Czecho-Slovakia, Belgium, Bergslagen, etc.).

*The relief valves* on the cylinder covers are in general use and are usually of large area (60-80 mm. diameter [2 3/8-3 5/32 inches]).

The Swedish Railways employ, on a few locomotives, combined relief valves and by-pass valves, of the Flodin type (already described in Mr. Lacoin's report, September 1921, page 1157) of the *Bulletin*.

*By-pass* valves are also much employed, without however being in completely general use.

These by-pass valves can be operated by hand, either direct or by means of compressed air), or else they are automatic. (Example in fig. 14.)

The Belgian National Railway Company, which also possesses some automatic by-pass valves, considers the non-automatics as preferable, on account of the fact that they enable a gentler start to be made from rest.

It should be stated that the Rumanian State Railways possess 90 *Pacific* locomotives, superheated, with four cylinders of equal size, with conjugated valve gear for each pair of cylinders, which are not fitted with by-pass valves, and these locomo-

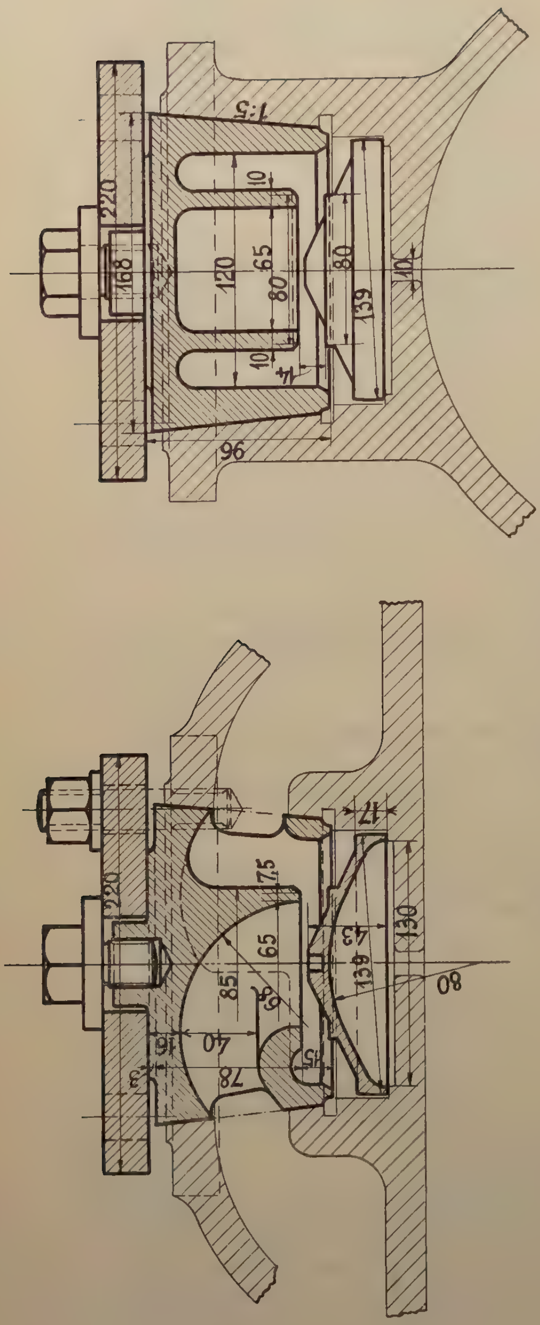

Fig. 14. — Automatic by-pass valve (Polish State).

tives, the first of which were supplied in 1913 and the last in 1923, have not given rise to any difficulty from the point of view we are considering. These locomotives, the cylinders of which are 420 mm. (26 1/2 inches) in diameter, are fitted with air valves 120 mm. (4 3/4 inches) diameter, placed on the steam supply pipes, into which, when the regulator is closed, a small jet of steam also enters, the purpose of which has already been mentioned in Chapter II, B. 1 (fig. 15).

It is to be noted on this subject that by-pass valves have the disadvantage of considerably enlarging the clearance-spaces in the cylinders, which has a detrimental influence on the compression of the steam, and consequently on the economy of the locomotives, especially if the cylinders are small in diameter. It however seems to be established that their use does not involve any appreciable disadvantage so far as locomotives with two equal cylinders, of relatively large diameter, are concerned.

As regards the question of whether it would be advantageous to use air valves and by-pass valves simultaneously, the majority of the replies received are in the affirmative, and it seems that the opinion that the locomotive runs more freely if both fittings are used predominates amongst the administrations covered by our inquiry. The question, however, does not seem to have yet been definitely settled.

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## CHAPTER III.

### Feed water heating.

#### 1. — Number of engines fitted.

The following table sums up the present position from the point of view of

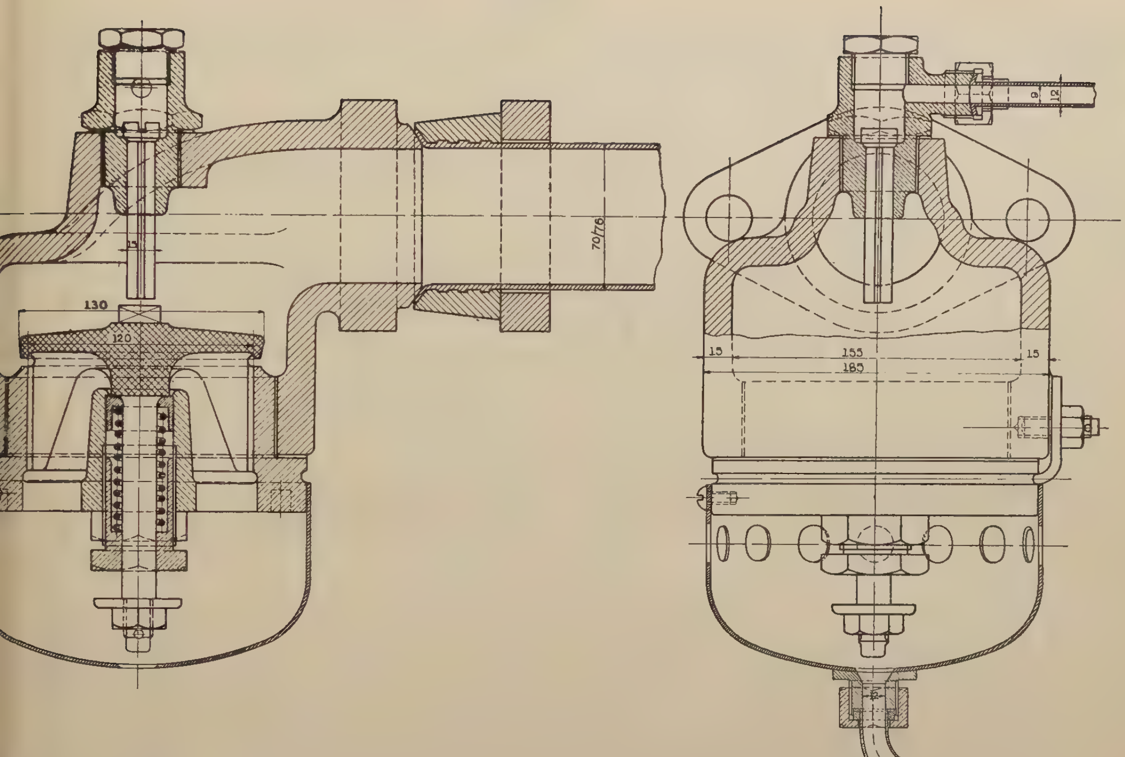

Fig. 15. — Air valve with steam jet applied when running with regulator closed (Rumanian State).

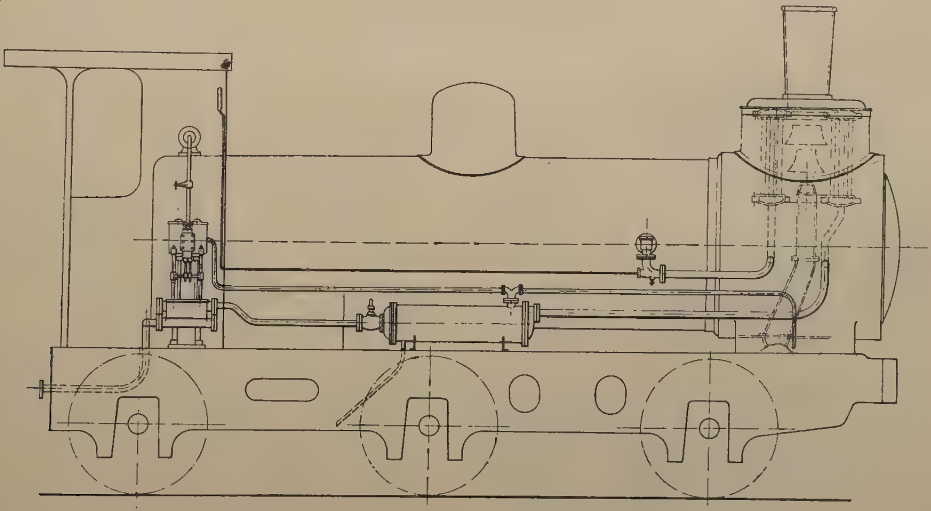

Fig. 16. — Anderberg type feed water heater (Swedish State).

| ADMINISTRATIONS. | Exhaust steam heaters. | | | | | | | | Exhaust and waste heate |
|---|---|---|---|---|---|---|---|---|---|
| | Mixing. | | | | | | Surface. | | Surfa |
| | Injectors. | | With pump. | | | | With pump. | | With p |
| | Davies and Metcalfe (Engl.) | Friedmann (Vienna). | ACFI type RM. | Dabeg. | Worthington. | Caille-Potonié, type RS. | Knor . | Schichau. | Anderl (Swedi |
| 1. Belgian National Railway Company. | 522 | ... | ... | ... | Experimentally. | Experimentally. | On engines of German origin. | ... | ... |
| 2. Swiss Federal Railways. | ... | 5 | ... | ... | 4 | ... | ... | ... | ... |
| 3. Czecho-Slovakian State Railways. | .. | 534 | ... | ... | ... | ... | 10 | ... | ... |
| 4. Polish State . . . | 18 | 295 | ... | 4 | 2 | ... | 20 | ... | ... |
| 5. Danish State . . . | ... | ... | ... | ... | 30 | ... | 16 | ... | ... |
| 6. Swedish State . . | ... | 1 | ... | ... | 1 | ... | 77 | 6 | 6 |
| 7. Finnish State. . . | ... | 50 | ... | ... | ... | ... | 20 | ... | ... |
| 8. Netherlands. . . . | Some locomotives. | ... | .. | ... | ... | ... | The majority of locomotives. | ... | ... |
| 9. Rumanian State . | ... | 34 | ... | 2 | ... | ... | 100 | ... | ... |
| 10. Jugo-Slavian State. | ... | Under trial. | Under trial. | ... | Under trial. | ... | Under trial. | ... | ... |
| CARRIED FORWARD. | 540 | 919 | ... | 6 | 37 | ... | 243 | 6 | 6 |

| INISTRATIONS. | Exhaust steam heaters. | | | | | | | | Exhaust steam and waste gas heaters. |
|---|---|---|---|---|---|---|---|---|---|
| | Mixing. | | | | | | Surface. | | Surface. |
| | Injectors. | | With pump. | | | | With pump. | | With pump. |
| | Davies and Metcalfe (Engl.) | Friedmann (Vienna). | ACFI type RM. | Dabeg. | Worthington. | Caille-Potonié, type RS. | Knorr. | Schichau. | Anderberg (Swedish). |
| ROUGHT FORWARD. | 540 | 919 | ... | 6 | 37 | ... | 243 | 6 | 6 |
| orwegian State. | 27 | ... | ... | ... | ... | ... | 78 | ... | ... |
| ergslagen . . . | 3 | ... | ... | ... | ... | ... | ... | ... | ... |
| rince Henry Rail-ys and Mines. . | ... | Some locomotives. | ... | ... | ... | ... | Some locomotives. | ... | ... |
| oximate total m of figures en). | 570 | 919 | ... | 6 | 37 | ... | 321 | 6 | 6 |
| lsace-Lorraine information, see ve). | 3 | ... | 197 | ... | ... | ... | 566 | ... | ... |

the extension of the application of the different types of feed water heaters to the locomotives of the administrations covered by the present report.

The position with regard to the Alsace-Lorraine (as administrators of the Guillaume-Luxembourg Railway) is not included in the résumé, in order to avoid a repetition of the figures already contained in the report dealing with French railways.

From an examination of this table, it results that the feed water heater, which is in most widespread use, in the administrations we are concerned with, is the exhaust steam injector supplied by Messrs *Friedmann* of Vienna, which is a simplification of the *Davies & Metcalfe* exhaust steam injector, itself widely used, and principally in Belgium.

Then follows the *Knorr* heater, the other types (Worthington, Schichau, Dabeg, Anderberg) only being fitted on a relatively limited number of locomotives belonging to these administrations. The A. C. F. I. heater is represented by a large number of appliances on the Alsace-Lorraine Railways.

The arrangements met with are all well known.

We reproduce in figure 16 the general arrangement of the Swedish Anderberg heater, in which the water is first heated in a small preliminary heater by the exhaust steam, and afterwards passes into the main heater, placed in the smoke-box, at the base of the chimney, where it is submitted to the action of the products of combustion.

### 2. — Information relating to the apparatus.

a) *Facility of operation. The ascertainment of the normal running and of the temperature obtained.*

It will be seen from the information received that the operation of all the feed water heating appliances used does not in general present any difficulty. The Friedmann exhaust steam injectors, especially those of the latest LF type, with automatic opening of the exhaust steam valve, are operated as simply as an ordinary injector, and moreover, in a manner similar to the Davies & Metcalfe, type H injectors in which the manipulation of the injector is reduced to the operation of a single hand wheel. It should be stated, however, that certain administrations consider the operation of the injectors a little delicate, although simple.

The exhaust steam injectors do not comprise any special arrangement for controlling their working; it is sufficient, as with an ordinary injector, to watch the water level in the boiler.

As to the temperature obtained, a thermometer can obviously be placed in the delivery chamber of the injector, but practice has shewn that this is superfluous, the staff very quickly becoming accustomed to feeding with hot water by the exhaust steam injector, and do not require any apparatus for checking the temperature. Thermometers are, moreover, rather liable to get out of order.

For feed water heaters incorporating a pump, set in motion either by live steam from the boiler or by the locomotive mechanism, the operation is generally equally easy, and only comprises the operation of the steam supply to the pump (for the first category), and the observation of its running, *i. e.*, of its delivery. Generally, there is to be found in the driver's cab a pump speed indicator (active stroke counter), but obviously the best check is to watch the water level in the boiler. The silent running of the pump is also an indication that it is running properly. These pump heaters generally include a thermometer fitted to the delivery pipe from the heater, shewing the temperature of the water delivered into the boiler. These thermoters are not entirely satisfactory from the point of robustness, and are therefore dispensed with in ordinary service, and the Engineers are content with being able to bring a thermometer into temporary use for test purposes.

b) *Average temperature of the feed water.*

With exhaust steam injectors, the temperature varies between 80° and 95° C. (176° and 185° F.), according to running conditions, and may reach and even exceed 100° C. (212° F.) if the locomotive is working to its full capacity.

For the other various types of pumps, the following average temperatures are obtained :

« Knorr » system 80° to 85° C. (176° to 185° F.) approximately.

« Worthington » system 100° C. (212° F.) approximately.

« Dabeg » system 70° to 90° C. (158° to 194° F.) approximately.

« A. C. F. I. » system 90° to 100° C. (195° to 212° F.) approximately.

These figures are capable of being appreciably exceeded at high speeds (generally up to about 120° C. (250° F.). During a run, the temperature may differ from the averages shewn by about 20° C. (36° F.).

### c) *Results of trials.*

In general few trials have been carried out for the purpose of determining the amount of water delivered and the consumption of live steam due to the installation of feed water heating. The only figures with which we have been supplied are as follows :

With the Friedmann exhaust steam injector, it is necessary to deliver a little live steam into the apparatus, which, by means of the exhaust steam alone, can only overcome the pressure existing in the boiler if the latter is, at the most, 11 kgr. (156.4 lb. per sq. inch) approximately; the small quantity of live steam admitted helps to overcome the surplus pressure. The Czecho-Slovakian State Railways inform us that the consumption of high pressure steam necessary represents approximately 2.8 % of the quantity of feed water introduced into the boiler.

It may be stated, however, that in exhaust steam injectors, the live steam returns in its entirety into the boiler, so that there is no consumption in the real sense of the word.

In regard to the pumps, the Polish Railways supply us with the figures of 2 % of the weight of water delivered as the consumption of live steam of the pumps (Dabeg, Worthington, Knorr), and the Alsace-Lorraine Railways the figure of 3 % for the A. C. F. I. pumps.

### d) *Coal economy (for equal power). Increased power (the coal consumption being equal). Water economy.*

The fuel economy due to the application of a feed water heater and ascertained under ordinary service conditions, is as follows for the various types of heaters :

Friedmann exhaust steam injector 5 % to 12 % (generally 8 % to 10 %).

Davies & Metcalfe injector 5 % to 12 % (during trials up to 24 %).

Knorr heater 8 % to 12 %.

Worthington heater 5 % to 12 %.

Dabeg heater 12 % (during trials up to 20 %).

A. C. F. I. heater 9 % to 12 %.

It is to be noted that the figures relate, in general, to the economy realised by considering the total fuel consumption (lighting up and standing times included).

The coal economy moreover depends to a large extent, as pointed out by the Polish State Railways, on the gradients of the line negotiated. If the line comprises alternately up and down gradients, the economy is reduced; on the contrary, it improves in the case of a continuous climb. It may be said in general that the higher the speed, over a longer period, the greater does the economy become.

The increase in power, for an equal fuel consumption, may be reckoned in general as almost equal to the figures indicating the fuel economy.

Finally, as regards the water economy obtained, all the administrations state that this takes place, but only a few of them have estimated it.

With the Friedmann injector, the economy ascertained by the Czecho-Slovakian Railways during the course of trials was 16.5 %, but in ordinary service the figure is naturally less, and may be estimated at 6 % to 8 %. On the Rumanian Railways also water economies of 9 % to 10 % were ascertained by means of trials.

As regards the A. C. F. I. heater, the Alsace-Lorraine Railways estimate that the water economy obtained was 15 %.

### e) *Influence of the application of the feed water heater on the superheated temperature of the steam.*

Few tests have been made on this subject, and opinions are rather different. In general, the Administrations are of the opinion that the application of feed water heaters does not involve a diminution, even small, in the temperature of the superheated steam produced by the boiler, on account of the decreased draught as the result of using a portion of the exhaust steam, and in fact, if the pressure of the boiler is always easily maintained at the working pressure, it appears that no adverse influence can be exerted on the superheat temperature.

We must, however, state that the Belgian National Railway Company inform us that for equal power, decreases in the degree of superheat have been ascertained; locomotives giving, before the A. C. F. I. feed water heater was fitted, 350° C. (662 F.) as the temperature of the steam, now only give approximately 340° C. (644° F.) after it has been fitted.

### f) *Influence on the blast.*

A few administrations have carried out experiments in connection with this point. The Polish Railways have measured the pressure at the blast pipe of the O. S. 24 type locomotives, before and after the starting up of the *Metcalfe* injector, and have obtained the following figures :

Before starting up the injector 40-45 cm. of mercury (1.53-1.60 abs. atm.).

After starting up the injector 20-30 cm. of mercury (1.34-1.40 abs. atm.), which therefore represent a diminution in the back pressure of 8 % to 9 %.

With the *Dabeg* feed water heater, similar figures were obtained.

The Czecho-Slovakian Railways state that about 16 % of the exhaust steam is taken from the feed water heater; the draught must be regulated accordingly. The Belgian National Railway Company has ascertained, that, for equal power, the vacuum in the smokebox was decreased by about 20 %, and the back pressure was reduced proportionately.

In spite of these facts, in practice no trouble has resulted from the application of exhaust steam feed water heaters. A few administrations have left it to the sheds to make the necessary small adjustments in the blast pipe orifice, others having found it unnecessary to do this.

### g) *Influence of the feed water heater on the partial purification of the feed water before it is introduced into the boiler.*

It appears that no special observation has been made on this subject.

With regard to exhaust steam injectors, it is certain that owing to the speed with which the water is discharged into the boiler, the deposits which are formed in the apparatus are insignificant, so that no improvement is obtained from the point of view we are concerned with; but, on the other hand, on account of this fact, the efficiency of the apparatus always remains the same, and the upkeep is thereby much reduced. It may therefore be considered that, on the whole, from the point of view of feed water heating, these arrangements rather improve the feed water.

As regards pump feed water heaters, especially surface heaters, it seems proved beyond doubt that the apparatus, whilst heating the water, effects the removal of the scale-forming matter and gases in the latter. However, the administrations are not yet in a position even to estimate the effect of this purification on the boiler maintenance costs.

We may state that the Czecho-Slovakian Railways are using, on those lines where the water is bad, an arrangement (Vesely system), the object of which is to remove the deposits before the water enters the boiler.

### h) *Oil separators.*

All the exhaust steam feed water heating devices of the mixing type incorporate an oil separator, places on the exhaust steam supply pipe, before the steam enters the heater.

In the Friedmann injector, the separation is effected by changing the direction of flow of the steam by means of suitable deflectors. The mixture of oil and condensed water escapes through an automatic drain valve. The Davies & Metcalfe injectors are fitted with centrifugal separators based on the same principle, and also incorporating a perforated cylinder covered with a fabric through which the steam is obliged to pass.

The A. C. F. I. heater R. M. type, also includes an oil separator, composed of a series of parallel partitions.

All these devices seem to answer their purpose, since the administrations agree in stating that no trouble has been reported from the fact of oil being carried into the boiler. It is estimated that, in general, the proportion of oil which is nevertheless carried through to the boiler amounts — as near as can be stated — to a few milligrammes per litre of water.

### i) *Performance in service of feed water heaters. Running maintenance.*

As regards the *Friedmann exhaust steam injector*, the administrations who use it are unanimous in recognising its good performance in service, and the lowness of its maintenance costs, which is explained by the absence of moving parts. Maintenance work is confined, as for ordinary injectors, to replacing or repairing a few injector cones. The Czecho-Slovakian Railways inform us for example (after five years' experience) that remplacements of the steam cones become necessary about every two years, without its being necessary to replace any other part. When the periodical examinations of the locomotive are carried out, the exhaust steam injector has, like any other injector, to be cleaned, and the cones are checked to see if they are correctly in place, etc. As we have already mentioned, the deposits which form in the apparatus, are very small.

The *Davies & Metcalfe injector* gives the same satisfactory results.

With *feed water heaters with pumps*, the maintenance costs are appreciably higher, and this naturally follows, as the equipment is much more complicated. The principal cause of the increased maintenance is that in all these devices chalk deposits take place which have a tendency to block the pump passages, and which necessitate rather frequent cleaning, so as to maintain the efficiency of the apparatus. In addition, cases of leakages in the pump fittings are reported.

From the information we have received, it would appear that the maintenance costs are a little higher for the Knorr heater than for the Worthington heater.

The A. C. F. I. type heater, R. M. type, gives complete satisfaction on the Belgian and Alsace-Lorraine Railways.

On the other hand, the opinions on the « Dabeg » type heater are less conclusive. But it is only right to state that the number of these equipments fitted, in Poland and Rumania only, is far too small to enable any conclusions to be arrived at; moreover, it should be stated that in Austria the Dabeg heater has, according to the information we have to hand, been fitted on a very large scale during the last few years.

The instructions given to the sheds and drivers are generally drawn up in accordance with the instructions issued by the makers, both for operating and maintaining these feed water heaters.

To the question we put as to whether any cases had been noticed of water from the feed water heater being carried to the cylinders, all the administrations have replied in the negative.

### j) *Measures taken to avoid the effects of frost in feed water heating devices.*

So far as exhaust steam injectors are concerned, there are no special measures to be taken beyond those taken for non-lifting injectors of the ordinary type. Whilst running or standing in stations, the injectors work continuously, so that there is nothing to fear from freezing. Once the run is completed, and the engine placed in the shed, all the supply pipes are closed, and the apparatus emptied by opening the cocks fitted for this purpose.

In countries which are extremely cold in winter, as in Finland and Sweden, the pipes are protected with lagging, and the injector itself is enclosed in a case.

In the case of the A. C. F. I heater, the following measures are prescribed, and give the desired results :

Before leaving the shed, see that the water flows properly through the ball and socket connection between engine and tender, then close the tender stop valve, couple up the ball and socket connection, and for a few minutes flush all the pipes of the apparatus with steam by means of the cock for heating up the ball and socket connections. Finally, close this cock again, open the tender stop valve and close the drain cocks.

When running, the only special precaution to be taken is to never completely close the valve supplying steam to the pump. In the cases of prolonged stoppages, open the cock for heating up the ball and socket connections and allow the pump to run slowly (two or three strokes per minute).

Finally, on arriving at the shed, close the tender stop valves, uncouple the ball and socket connections, open the drain cocks, allow the pump to make a few more strokes so as to empty it completely, then shut off the pump steam supply.

As regards the *Dabeg* pump, attention must also be paid to the draining of the apparatus. To do this in the simplest manner, whilst the equipment is working, it is only necessary to close the suction pipe, which causes the cold water pump, also the injector heater and the hot water pump to be emptied.

In the case of the *Worthington heater*, immediately the engine is finished with, the drain valve is also opened, the piston is allowed to make a few idle strokes to empty the pump.

In the case of the *Knorr heater*, during prolonged stoppages, the water may be circulated between the heater and the pump, without its going into the boiler. Once the locomotive has returned to the shed, the draining of the apparatus must be carried out, by allowing the pump to run idly for a few minutes.

### k) *Maintenance costs of feed water heaters, per kilometre and per annum.*

The Alsace-Lorraine Railways have supplied the following maintenance cost figures :

A. C. F. I. apparatus: 537 French francs per apparatus per annum.

21.90 French francs per 1 000 train-km. (35.24 French francs per 1 000 train-miles).

Knorr apparatus : 778 French francs per apparatus per annum.

29.15 French francs per 1 000 train-km. (46.90 French francs per 1 000 train-miles).

The Czecho-Slovakian Railways have also supplied some figures, as follows :

Friedmann exhaust steam injector : 100 Czech crowns (75 francs) per apparatus per annum.

1.50 francs per 1 000 train-km. (2.41 fr. per 1 000 train-miles).

These are the only figures at our disposal, the majority of the administrations not having figures on this subject.

### l) *Financial advantages.*

As regards exhaust steam injectors (Metcalfe or Friedmann), it is considered that the apparatus pays for itself at the end of three years at the most, taking into account the purchase price, fitting and maintenance costs, and the economies obtained by the apparatus.

The A. C. F. I feed water heater pays for itself in about four years (taking the mean of the figures supplied by the Alsace-Lorraine Railways and the Belgian National Railway Company).

The Knorr heater is considered as paying for itself in about the same period of time, and the Worthington type in somewhat less time.

### m) *Weights of equipments.*

The increased weight of the locomotive on account of a feed water heater being fitted (compared with an ordinary injector), including the water in the apparatus, is, from the information received, on the average, as follows :

Dabeg heater, 1 000 kgr. (2 204 lb.) approx.

Worthington heater, 800 to 1 000 kgr. (1 764 to 2 204 lb.) approx.

Knorr heater, 800 to 1 200 kgr. (1 764 to 2 645 lb.) approx.

A. C. F. I. heater, 1 200 kgr. (2 645 lb.) approx.

Anderberg heater, 1 000 kgr. (2 204 lb. approx.

Exhaust steam injector, 150 to 250 kgr. (330 to 550 lb.) approx.

### 3. — **Conclusions with regard to feed water heaters.**

The opinions of the different administrations are generally favourable to exhaust steam injectors, especially on account of the fact that their efficiency does not diminish as time goes on, whereas the efficiency of the equipment comprising pumps may diminish by reason of steam leakages in the pistons and valves; and as regards surface heaters, also on account of the lime deposits which take place. It would appear that the relatively low price of the exhaust steam injector, its lightness and its reduced maintenance costs cause it to receive special attention. However, all the equipments mentioned are in general working normally; but for many of the administrations the trials on an extended scale of all these devices are considered as still too recent to enable any definite conclusions to be drawn with regard to the superiority of one equipment over another.

One great advantage of all the feed water heaters is also found in the fact that the fireman's work is simplified, as he has not, broadly speaking, to concern himself with the feed water, and can pay more attention to his fire, and even also look out for signals at difficult points of the road. From this point of view, the « Dabeg » pump, which is actuated by the motion, and the delivery of which is actuated by the steam produced by the locomotive (since it depends on the cut-off) is of particular interest.

The majority of the administrations consulted are considering an extension of the application of feed water heaters, especially for powerful locomotives, both for passenger and freight work.

### 4. — Arrangements to prevent feeding with cold water when regulator is closed.

In the *Friedmann exhaust steam injector*, as soon as the regulator is closed, the pipe carrying the steam from the steam chest to the double-seated valve (placed near the suction valve) is emptied of steam, and the double valve is lifted by the live steam which flows towards the injector as long as the injector is working (auxiliary steam supply open), and allows the steam to enter the auxiliary live steam pipe, the injector then working like an ordinary injector, the steam space being automatically shut off from the exhaust steam pipe, which is empty for the time being. In the original *Davies & Metcalfe*, the driver himself opens a live steam supply cock.

In the *Dabeg* heater, the feeding of the boiler is only carried on whilst the locomotive is producing steam. The cold water pump, as a matter of fact, contains a regulator the position of which is determined by the position of the reversing rod of the locomotive, and according to the position of this latter a greater or smaller quantity of cold water coming from the tender is delivered by it, the remainder only passing into the injection heater. In the mid position or in full gear, corresponding to the closed regulator, the whole of the cold water brought along by the pump, which works as long as the locomotive is running, is sent back to the tender and feeding with cold water is avoided. To feed the boiler during stoppages, which is nevertheless sometimes necessary, the stand-by injector provided on the locomotive is used.

The *Knorr* equipment comprises, for the purpose we have in mind, either an automatic valve for shutting off the steam used for working the pump, which stops this at the same time as the regulator is closed, — or an automatic valve which delivers live steam to the heater, to replace the exhaust steam, as soon as the regulator is closed. Both these fittings are automatic valves operated by the steam from the steam chest, one being open and the other closed, by the action of this steam.

In the *Worthington* heater, an automatic arrangement also ensures the heating of the water during stoppages or when running with the regulator closed, but this feed should not as a general rule be used, the pump running at sufficient speed while the regulator is open, to maintain the water level in the boiler, and should normally be stopped when the regulator is closed.

All these arrangements, therefore, employ *live steam* to make up for any lack of exhaust steam during the periods when the feeding of the boiler is continued with the regulator closed.

In the *A. C. F. I.* equipment, RM. type, a *reserve of hot water* is used with the same object in view. A reservoir of about 500 to 1 000 litres (111 to 222 gallons) capacity, is placed at a position lower than the mixing heater, between the suction vessel and the overflow of the heater. By means of two by-passes (one for suction and the other for discharge) operated by the live steam coming from the steam chest and by a three-way cock placed in the cab and which may intercept the communication between the two by-passes, when the absence of pressure of the steam coming from the piston valves causes the by-passes to take an appropriate position, the cold water pump draws from the supplementary water reservoir (in which the temperature of the water received from the overflow whilst running with the regulator open is about 100° C. (212° F.), and the water drawn in, again passing through the heater, to which both the exhaust from the water pump and also that from the air pump is led, is finally returned to the second cylinder of the tandem pump.

This arrangement is preferably applied to locomotives hauling stopping trains, and the results obtained on the Alsace-Lorraine Railway with 11 locomotives so fitted are very satisfactory. A simplification of this arrangement is moreover under trial.

The increase in weight of the locomotive resulting from fitting the hot water reserve, is (including the weight of the water) 500 to 1 000 kgr. (1 102 to 2 204 lb.) for tender locomotives. As regards tank engines, on which the hot water reservoir is arranged by partitioning the ordinary water tank, there is practically no increase in weight.

## CHAPTER IV.

### Air preheating.

The administrations dealt with in this report have not in general made any tests with air preheating.

The Swedish State Railways have only fitted this on one turbine locomotive of the Ljungström type which does not come within the scope of this report. The Polish State Railways alone report that they have made tests with a device consisting of a cast iron member placed on the grate and occupying about 20 % of its area. However, the results of this trial have been very inconsistent, and one cannot at the moment draw any conclusions or give any description of the arrangement.

## CHAPTER V.

### Valve gears.

#### 1. — *Type of valve gear used.*

All the administrations concerned use the Walschaerts gear in their modern engines.

### 2. — *Valve gear characteristics.*

The table in Appendix 3 gives a summary of characteristics of the valve gears of a number of locomotives owned by the administrations who have furnished information.

### 3. — *Conjugated valve gears.*

Of the administrations concerned, the Belgian National Railway possesses 15 superheater express locomotives with three cylinders of equal diameter 500 mm. × 630 mm. stroke 19 11/16 in. diam. × 24 3/4 in. stroke) of the Prussian 4-6-0 type. The valves of the outside cylinders are driven by Walschaerts gear, while the valve of the inside cylinder is driven by the two outside motions. The cranks are set at 120° to each other which allows the inside valve to be driven through two levers connected to the outside valve spindles and each turn about a fixed centre which divides them in the ratio of 1 : 2. Figure 17 shows the arrangement and the principal dimensions of the valve levers. The three valves have equal leads when running at 40 % cut-off in fore gear. The compound engines owned by this Railway have independent gear with an arrangement allowing for working as a 4-cylinder simple. The intention is, however, for future compounds to have conjugate valve gears, as this simplifies and cheapens construction. A difference of 15 % between the high pressure and low pressure cut-off is intended with a cylinder ratio of 2.05 to 2.25.

The *Alsace-Lorraine Railways* have also some engines of German origin of the 2-10-0 ($G^{12}$) type with three equal cylinders 570 mm. (22 7/16 inches) diameter and 660 mm. (26 inches) stroke, the inside cylinder inclined. The two outside cranks are at 120° to each other while the inside crank is 122°21′ from the outside right hand crank and 107°39′ from the left hand crank. The inside valve is driven from the outside gearing by means of two parallel shafts, one of which oscillates in fixed bearings while the second oscillates in bearings carried on arms fixed on the former shaft (see fig. 18). The two outside valves have a constant lead of 5 mm. (13/64 inch) while the lead of the inside valve is variable. All the compounds of the Alsace-Lorraine Railways have independent valve gears.

The 4-cylinder compounds of the Norwegian State, the Swedish State and the Rumanian State, have, as a rule, one set of gear for the one high pressure cylinder and one low pressure on each side of the engine. The cut-offs are nearly always equal for these two cylinders. The same arrangement is found on the *Pacific* locomotives of the Rumanian Railways with four equal cylinders, there being one set of gear for each pair of cylinders. The diameter of the cylinders is 420 mm. (16 1/2 inches) and that of the piston valves 270 mm. (10 5/8 inches). The R. II type three-cylinder simple 4-6-0 engines of the Danish State Railways also have independent valve gear, the centre valve being driven by means of a special eccentric rod on the left hand side of the machine driving the expansion link by means of a rocking shaft. There are therefore two eccentric rods on the left hand side of the engine.

In general it will be seen from the replies received that the administrations have not carried out comparative tests or special investigations to determine whether conjugate or independent gears are to be preferred. However, it appears that independent gears are preferred in spite of their greater first cost and maintenance charges.

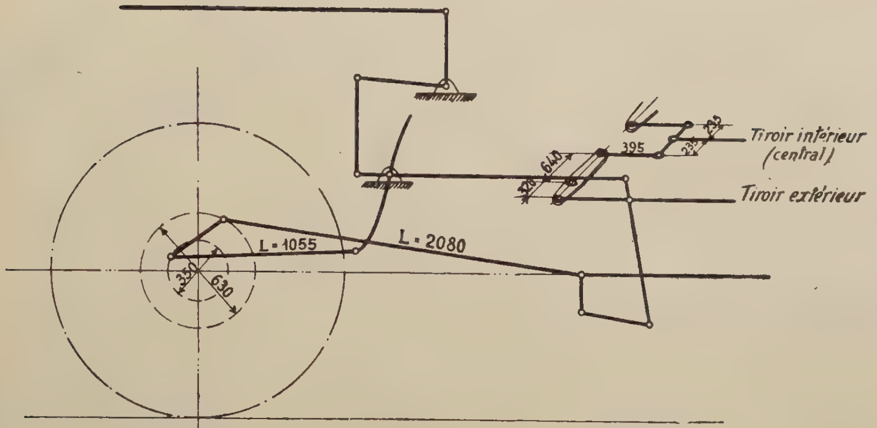

Fig. 17. — Conjugated valve gear. S 10² class
(Belgian National Railway Company).

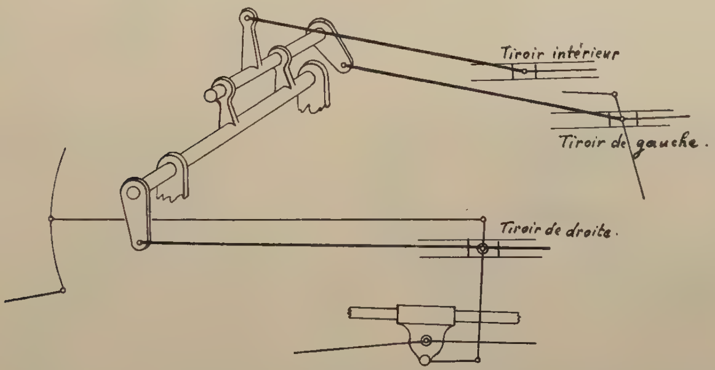

Fig. 18. — Arrangement of valve gear for 3-cylinder locomotive type G 12
(Guillaume-Luxembourg Lines).

*Explanation of French terms in figs. 17 and 18 :*
Tiroir de droite = Right hand valve. — Tiroir de gauche = Left hand valve.
Tiroir extérieur = Outside valve. — Tiroir intérieur — Inside valve.

### 4. — *Use of limited cut-off gears.*

None of the administrations concerned have made any tests of this nature.

### 5. — *Special valve gears.*

Only the Polish State and the Netherlands Railways have tested special valve gears.

The Polish Railways have fitted three of their engines with poppet valves, of which two of the Os 24 type are fitted with *Lentz* gear and the third (a passenger engine) has been experimentally fitted with a new type of gear known as the *Jendrusik*.

The Lentz gear used is the latest type with horizontal poppet valves, the cam shaft being driven by Walschaerts gear is placed horizontally and at right angles to the longitudinal axis of the cylinders. The valve chest forms a separate unit bolted to the cylinders (fig. 19).

This arrangement is provided with very light valves of pressed steel and gives rise to very small inertia forces while running and causes much less wear than the original arrangement of vertical valves and a longitudinal cam shaft. The maintenance cost and oil consumption have also been reduced.

The Polish Railways have obtained good results with this gear, the steam consumption has been found to be 0.7 kgr. (1.54 lb.) per horse power hour less than with piston valves. The running of the engine has been improved and its performance is said to be more uniform than with piston valves. As regards the *Jendrusik* gear which has been tested by the Polish Railways, this is a poppet valve gear driven by a special device including gear wheels. The trials have only just commenced and one cannot yet give any information on this gear, and the Polish Railways have only mentioned it without giving at present any drawings or description.

The Netherlands Railways have also some express locomotives fitted with *Lentz* valves and some with the *Meier Mattern* system in which the valves are driven hydraulically, but of which we have no description.

## CHAPTER VI.

## Smokebox and blast pipe.

### 1. — *Type of blast pipe adopted.*

As a general rule the fixed type of blast pipe nozzle placed low down in the smokebox has been adopted by the railways concerned. The normal section of the nozzle is determined assuming a good quality coal, this being modified by the use of a « jimmy » or liner if inferior coal is burnt.

There are also a number of variable blast pipes with a moving trefoil or adjustable flaps.

The table in Appendix 4 gives a summary of the dimensions of the blast pipes of some engines which have been supplied, and gives the essential ratios for these locomotives between the blast pipe, grate area, chimney, etc., particularly of the ratios $\frac{\Omega}{G}$ *i. e.* the number of square centimetres of blast pipe orifice per square metre of grate area, as a function of the ratio $\frac{G}{S}$ (grate area in relation to total free area through tubes).

### 2. — *Novel blast pipe arrangements.*

The Belgian National Railways have for some years fitted a double chimney and blast pipe on powerful locomotives of the 4-6-2 and 2-10-0 types; the grate area for the former is 5 m² (53.8 sq. feet) and for the latter 5.10 m² (54.9 sq. feet). A description of this double chimney will be found in the *Bulletin of the Railway Congress*, August 1926 number.

This arrangement has been gradually extended to all engines of these types and will be fitted in the future to all new engines having a grate area of more than 4.20 m² (45.2 sq. feet).

The Bergslagen Railway has also fitted for trial some three-cylinder express locomotives with a blast pipe having *separate concentric orifices* as shown in figure 20. Trials are in hand, and it is

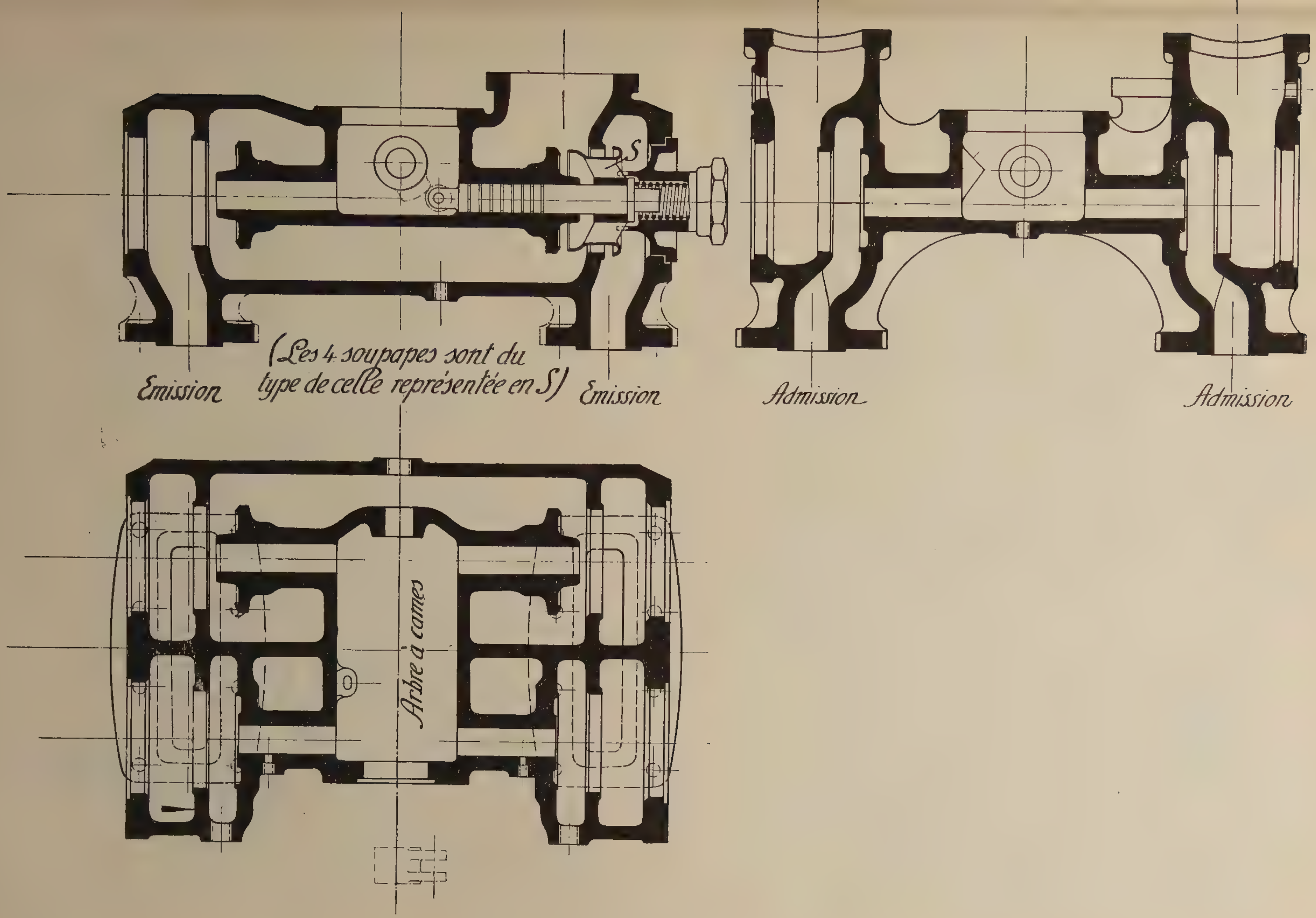

Fig. 19. — Lentz valve gear (Polish State).

*Explanation of French terms* : Admission = Admission. — Arbre à cames = Cam shaft. — Emission = Exhaust.
Les 4 soupapes sont du type etc.... = The four valves are of the type shown at S.

hoped that the three steam jets will not interfere with each other.

The Kylälä blast pipe is also being experimented with in several countries : in Switzerland on a 2-6-0 locomotive, in Sweden, on the Alsace-Lorraine Railway (Guillaume-Luxembourg). On this latter Railway this type of blast pipe has been fitted since 1926 to twenty 4-cylinder compound engines (S. 9 type) and will also be fitted to 4-6-2 (S. 14 type) and 2-8-0 (G. 14 type) locomotives. The Finnish State Railways which during the war adopted the Kylälä blast pipe have decided not to extend its use. It appears, however, that this blast pipe increases to a certain extent the vacuum in the smokeboxes, reduces the amount of sparks thrown, and is relatively cheap to maintain. Opinions, however, differ.

### 3. — *Novel methods of improving the draught.*

Of the administrations concerned only the Polish Railways have tried the *Langer* arrangement, which is known as a draught controller (1). This system includes a number of sheet metal partitions arranged in the smokebox (see fig. 21), which form a series of compartments with the object of damping out the varying forces of the blast and producing an even regular draught of average intensity, so as to improve the combustion and to reduce the amount of sparks thrown and to produce in this way an economy of fuel. This has been proved by tests made in Poland on four engines (types TR 12, TY 23 and Os 24) which when using coal having an average calorific value of 6 000 calories per kgr. (10 800 B. T. U. per lb.) showed a fuel economy of 6 % increasing up to 13 % with coal of inferior quality. A great reduction in the smoke and the amount of sparks thrown has been very noticeable.

The encouraging results obtained have led the Polish Railways to decide to fit this device on a further number of engines so as to better prove its value.

According to our information, the Langer device has been successfully applied for two or three years, it appears, in Austria where it is already fitted on a number of engines.

The Rumanian State Railways have also decided to fit the Langer apparatus experimentally on two 4-6-0 passenger locomotives.

### 4. *Arrangements to prevent smoke obscuring the view of the driver.*

With the large modern boilers, on which the chimney is very short in order to clear the loading gauge, smoke is often very troublesome to the footplate staff and may in certain circumstances be dangerous by obscuring the driver's view of the signal.

In general, very little has been done to create an upward current of air behind the chimney to carry away the smoke and avoid the above disadvantages. The method which is most widely applied consists of placing behind the chimney deflectors of various sizes and shapes intended to produce the desired upward current of air behind the chimney. The Rumanian Railways have on many of their engines of Hungarian origin deflectors of this type (fig. 22), of sheet metal or cast solid with the chimney, and these are also used by the Bergslagen Railway. The results obtained with these devices do not appear to be very conclusive.

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(1) « Luftzugumformer ».

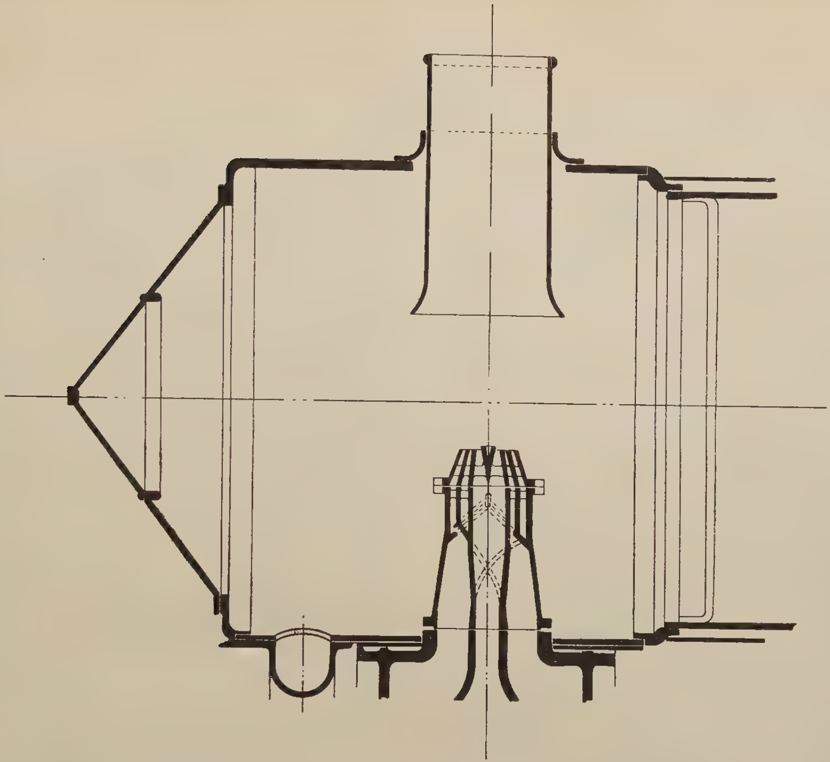

Fig. 20. — Triple blast pipe cap (Bergslagen Railway).

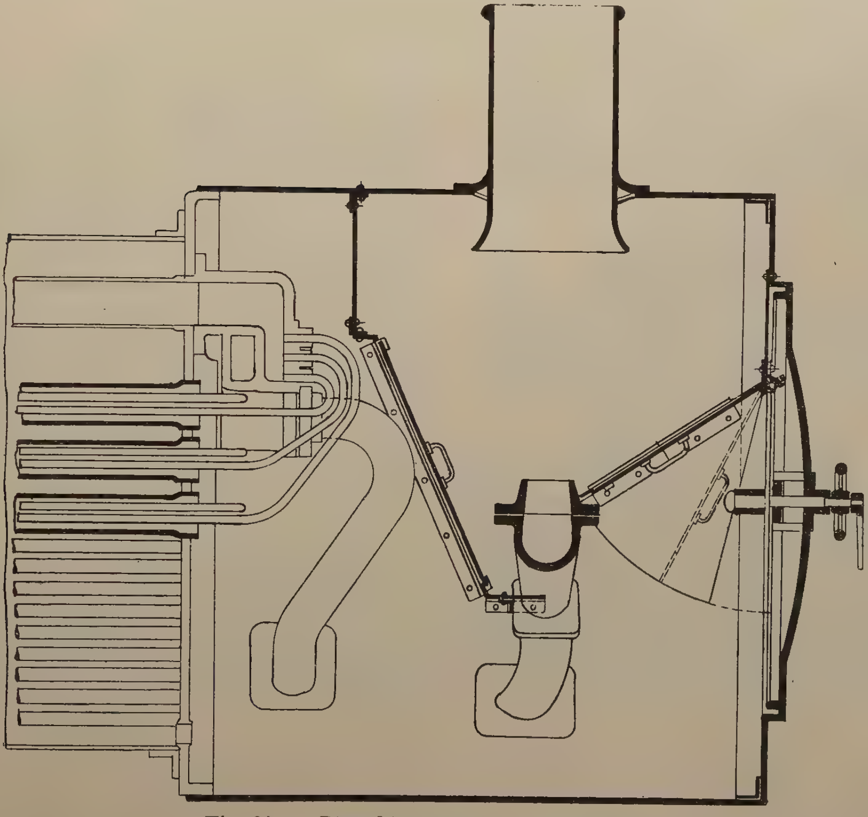

Fig. 21. — Draught apparatus, Langer system.

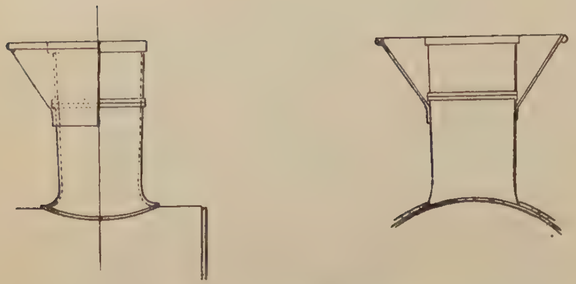

Fig. 22. — Smoke deflector.

The only arrangement which appears to give positive results is that generally used by the German State Railways (Reichsbahn) and which will also shortly be fitted on the Guillaume-Luxembourg Railway (Alsace-Lorraine) and on some of the engines of the Belgian National Railway Company. This device consists of two sheet iron plates placed parallel to the axis of the engine on either side of the smokebox, the front part of the engine platform forming inclined planes sloping down to the front so as to deflect upwards the current of air created by the motion of the engine and to cause this to flow between the smokebox and the plates in question (fig. 23).

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## CHAPTER VII.

## Other improvements of reciprocating locomotives.

### A. — Compounding.

1. — *Comparative tests made since 1922 between simple and compound superheated locomotives.*

Of the administrations dealt with, only the Norwegian Railways and the Belgian National Railways have carried out tests of this kind in recent years.

In Norway the trials took place in 1927 with the 4-cylinder 4-6-0 express locomotives, one simple with a working pressure of 12 kgr. per cm$^2$ (170.7 lb. per square inch), and the other a compound with a working pressure of 13 kgr. per cm$^2$ (184.9 lb. per square inch.). The simple engine also had *Ess* tubes (see chapter II) which gave it an advantage over the compound, nevertheless the latter showed a remarkable saving in fuel compared to the simple engine working under comparable conditions, but the exact amount of this economy is not stated.

On the Belgian National Railways the tests showed an economy of 7 to 10 % in favour of the compound. It appears, however, from these tests that this economy would be reduced or would even disappear if leakage past the valves and pistons were reduced to a minimum. For this reason the Belgian National Railway has reserved its judgment on this question.

The Czecho-Slovakian Railways, in view of the results obtained on actual service which generally show higher maintenance cost in the case of the compound which offset the additional saving obtained over the simple superheater have abandoned the use of compound engines.

The Rumanian Railways also share this view.

The Swedish Railways also consider it is unnecessary to compound superheater locomotives.

In short, opinion continues to be divided on the merits of compounding of superheater locomotives.

2. — *Type (simple or compound) adopted for engines built since 1922.*

In consequence of the opinions quoted above, certain administrations have only

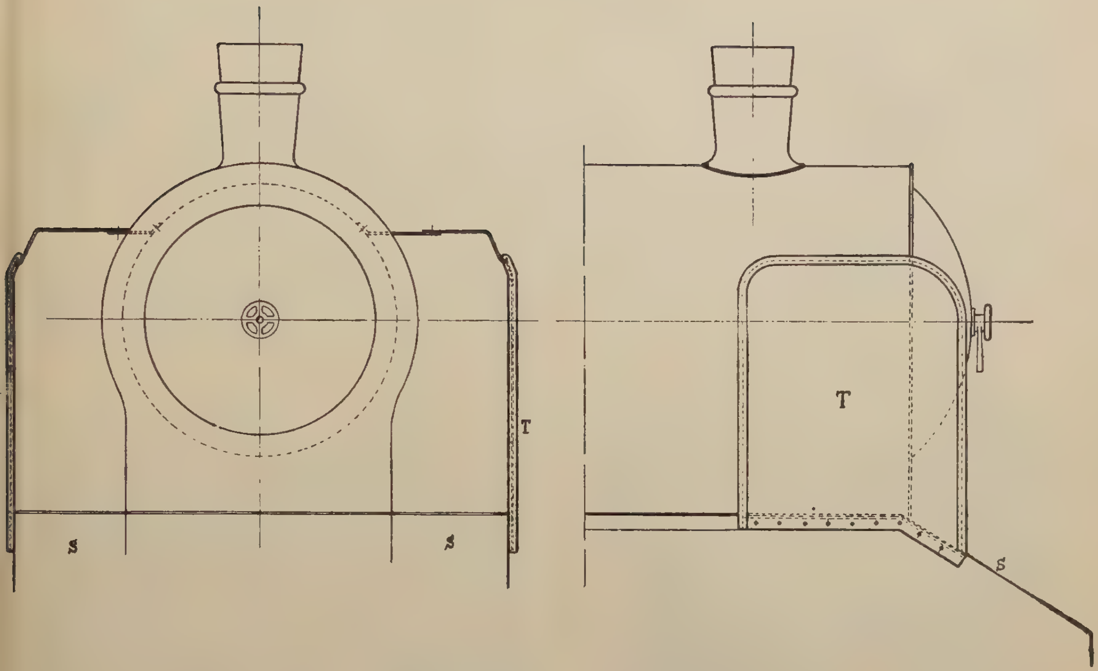


Fig. 23. — Arrangement for lifting smoke (German State Railways).

built simple engines during recent years. This is the case with the Czecho-Slovakian Railways, the Polish Railways, the Rumanian, Swedish, Dutch, Danish and the Serbian (S. H. S.) Railways. On the other hand the Belgian National Railway Company has built, since 1922, eighty-five 4-cylinder compound superheater locomotives and two hundred and twenty-five 2-cylinder simple locomotives. The Alsace-Lorraine Railways are also at present building compound engines.

### 3. — *Conversion since 1922 of simple engines to compound or vice versa.*

The only cases are where compound engines have been converted to simple. Thus the Czecho-Slovakian Railways have rebuilt the 354.6, 434.0 and 423.0 classes of saturated compounds to simple superheater engines, fitting them with superheaters with small diameter tubes.

In Sweden, the State Railways have also rebuilt some saturated compound engines as superheaters, and when cylinders required renewal have replaced them by simple expansion cylinders with piston valves.

The Alsace-Lorraine Railways have also experimentally converted one compound engine of the G. 11 class to a simple engine for shunting purposes.

### 4. — *Ratio between the volumes of high and low pressure cylinders as a function af the working pressure.*

From the information received it appears that the ratio in question ranges as a rule between the following limits for the pressures given :

Pressure 12 kgr. per cm$^2$ (170.7 lb. per sq. inch. Ratio 1 : 2 to 1 : 2.25.

Pressure 13 kgr. (184.9 lb.). Ratio 1 : 2 to 1 : 2.25.

Pressure 14 kgr. (199.1 lb.). Ratio 1 : 2.38 to 1 : 2.43.

Pressure 15 kgr. (213.3 lb.). Ratio 1 : 2.32 to 1 : 2.50.

Pressure 16 kgr. (227.6 lb.). Ratio 1 : 2.25 to 1 : 2.71.

### 5. — *Statistics.*

The table, Appendix V summarizes the situation on 1 January 1928, for the administrations with have kindly supplied information dealing with the number of simple or compound engines, saturated and superheated, with 2, 3 or 4 cylinders in their locomotive stock.

For the purpose of comparison the numbers for the 1 January 1922, are also given.

It will be seen from this table as regards the Administrations as a whole that the number of compound engines has decreased compared with the number of simple engines since 1922, the proportion of compound engines which was 19.1 % in 1922 being only 15.2 % in 1928.

Of the compound locomotives the majority are saturated engines and the superheater compounds have all with few exceptions 4 cylinders which shows that in general the administrations have decided to use compound superheaters only for the most powerful engines.

It may be noted with regard to the table that the increase in the number of compound engines on the Czecho-Slovakian State is not the result of new construction, but from the fact that in the interval private lines have been nationalised and that these engines are included in the stock of the State Railways.

## B. — **Improvements of combustion.**

### 1. — *Use of combustion chambers.*

None of the administrations dealt with possess engines fitted with combustion chambers.

### 2. — *Special grates.*

There is nothing to be mentioned except perhaps the *Schlangerenrost* firebars of the Swedish State Railways (serpentine bars, see fig. 24).

### 3. — *Smoke consuming devices.*

Apart from the Swiss Federal Railways which have used since 1906 their own system, only the Polish Railways have recently made tests with the system supplied by the Langer Fuel Saving Corporation of America, which is additional to the apparatus for improving the draught of the same name, and which has been dealt with in a previous chapter. The Langer device is known as the « pyramid fire » (*Pyramidenfeurung*) which consists of a short brass nozzle fixed to the firebox doorplate from which are projected into the firebox six jets of steam in the direction of the brick arch and forming a pyramid the summit of which is the aforesaid nozzle, and which directed downwards on to the grate covers the triangular area, the apex of which is at some distance from the firebox doorplate and the base is beneath the brick arch, the area being subjected to the pyramidal jet of steam produced (see fig. 25).

The air which is prevented by this jet from entering this part of the grate is forced to enter at the sides of the firebox and to a greater extent towards the doorplate than towards the tubeplate. This air considerably increases the combustion along the side walls of the firebox and

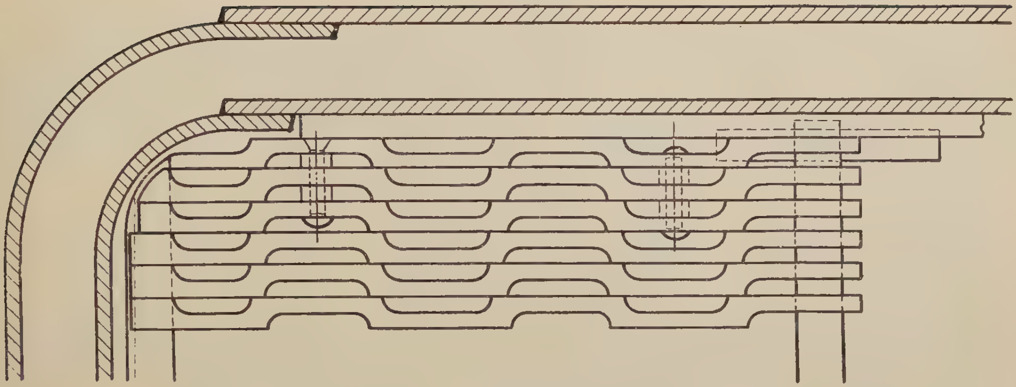


Fig. 24. — Firebars (Swedish State).

moreover the products of combustion in their path towards the tubeplate meet the jet of steam which spreads towards the tubeplate and are forced to turn back and pass along the side walls and roof of the firebox thus increasing the effectiveness of the direct heating surfaces.

The gases thus have to take a longer path in the firebox and by the changes in direction to which they are subjected turbulence is set up which improves the combustion and reduces the amount of smoke given up. The apparatus also includes an automatic blower which is opened when the regulator is shut and the firehole door allows air to enter after each period of firing.

Tests made in Poland in 1928 have given satisfactory results, and the Polish administration intends to extend its application of this device, the cost of which is not great and the operation of which does not appear to give any difficulty. We are informed that in Austria the Langer smoke consuming apparatus is also stated to give a coal economy of at least 10 to 12 %, especially on passenger trains. The economy appears to be due not only to the more perfect combustion of the gases, but also to the fact that the fuel under the steam pyramid burns more

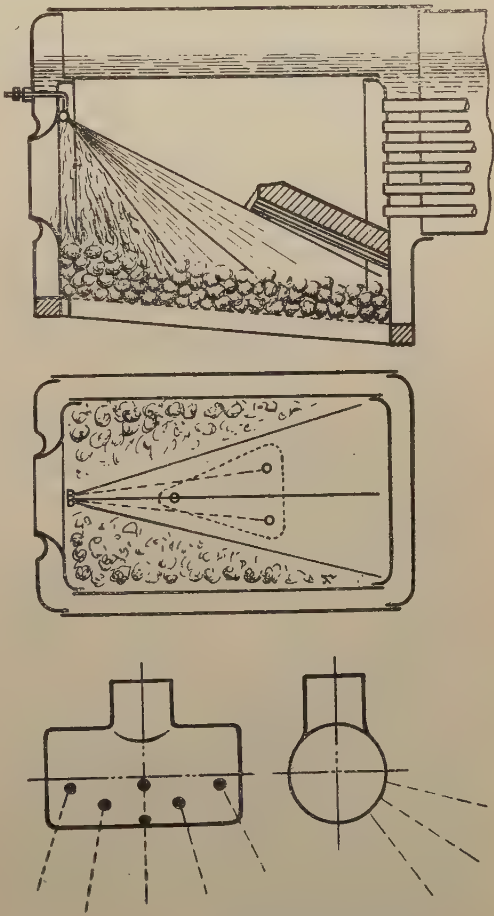


Fig. 25. — Langer steam pyramid.

slowly and has not to be replenished so frequently.

The Rumanian Railways have also decided to fit the Langer Steam Pyramid, as well as the draught arrangment in the smokebox to two 4-6-0 engines for purposes of trial.

It may be mentioned that the Langer device does not give the whole of the advantages mentioned except when fitted in conjunction with the draught modifying device mentioned in chapter VI, item 3, the two devices forming a complete apparatus for improving the draught and combustion.

### C. — Devices for improving circulation of water in existing boilers.

A number of administrations have tried similar devices. The Czecho-Slovakian Railways have fitted the copper firebox of one of their 3860.0 class (4-6-2 with three equal cylinders) with four mild steel tubes 66-76 mm. (2 19/32-2 63/64 inches) diameter, covered with a layer of copper. The brick arch is carried on these four tubes. The engine in question has only been fitted with this arrangement a short time, and no conclusions have yet been drawn as to the advantages of the system.

The Polish State Railways have also 35 engines fitted for trial with water circulating tubes of the Madeyski pattern, figure 26. These trials are still in hand.

The Belgian National Railway Company possesses 150 freight locomotives of the 2-8-0 type of American construction fitted with three tubes carrying the arch. The fireboxes of these engines are of copper. This arrangement is considered by the Belgian Company to be advanteageous as it carries the arch, which is not of built up brick work.

Finally, the Finnish Railways use Thermic syphons. We have no information on the maintenance cost of these devices.

We have not been informed of any cases of a false water level being attributable to this device.

### D. — Regulators.

#### a) *New types of regulators tried.*

It appears that no trials have been carried out with new regulators placed in the dome on the Railways we are concerned with, the most widely used being such well-known types as the Schmidt Wagner, Improved Zara, or double-beat regulator. The only exception is the Guillaume - Luxembourg (Alsace - Lorraine) which has tested the Lejeune regulator consisting of 8 valves, 48 to 54 mm. (1 57/64 to 2 1/8 inches) diameter arranged in a circle and opening successively in a definite order. On some engines the regulator was difficult to operate. In spite of the satisfactory results obtained on other engines, it appears that the tests are not being continued.

#### b) *Regulators placed between the superheaters and cylinders.*

This system appears to be advantageous for shunting engines fitted with superheaters to enable them to start up as quickly as possible when shunting. On the other hand, the steam is well superheated when it reaches the cylinders, and the continuous presence of steam in the elements has the effect of preserving these.

However, few regulators of this type have been fitted by the Administrations we are dealing with. They are only found in Sweden on the State Railways and on the Bergslagen Railway. Figure 27 shows the arrangement adopted by the latter.

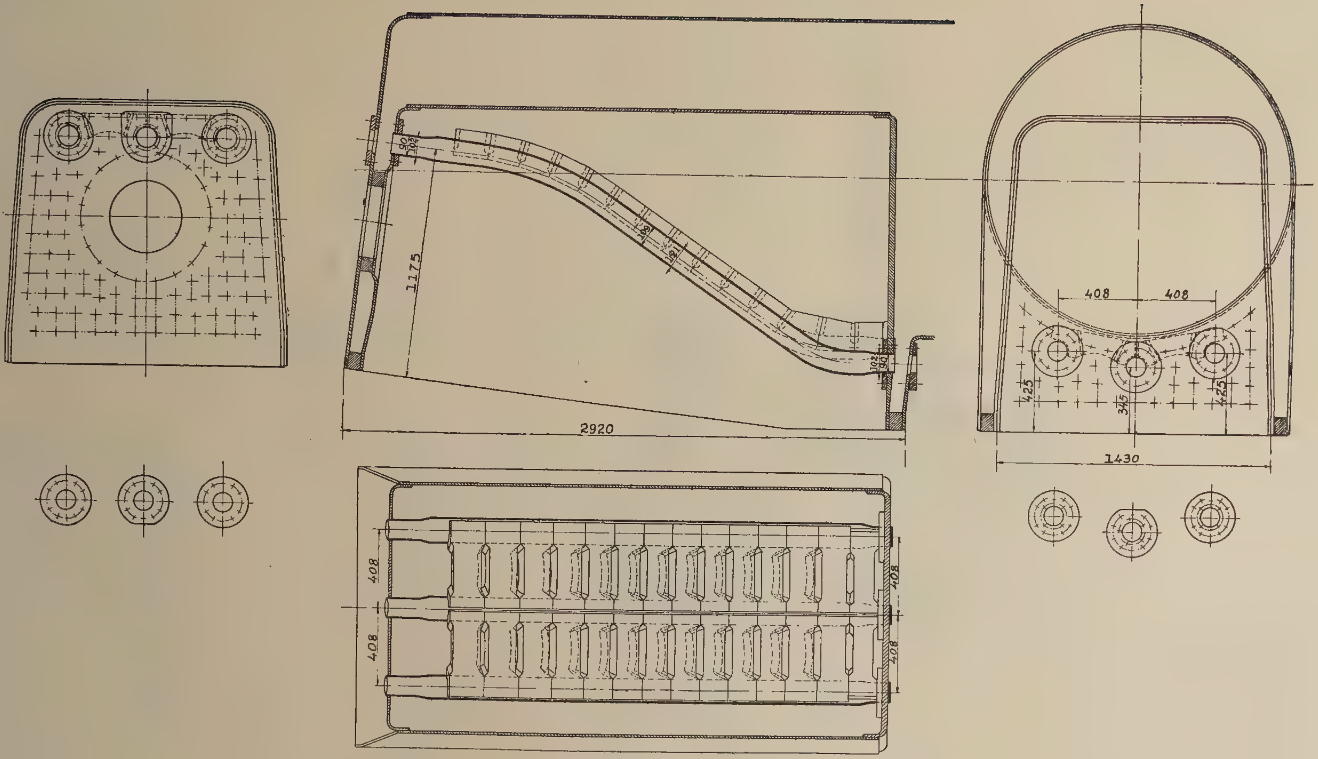


Fig. 26. — Madeyski water tubes and brick arch (Polish State Railways).

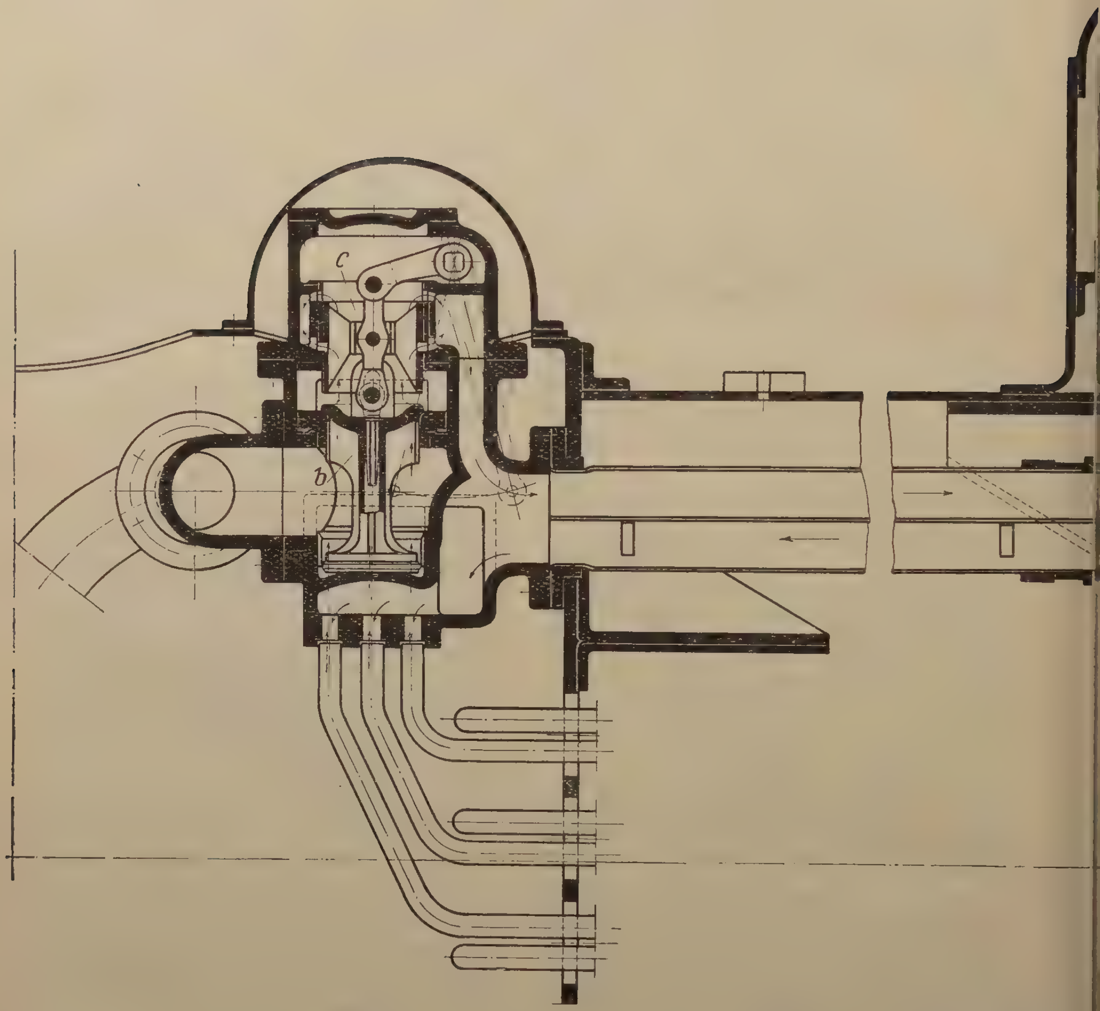
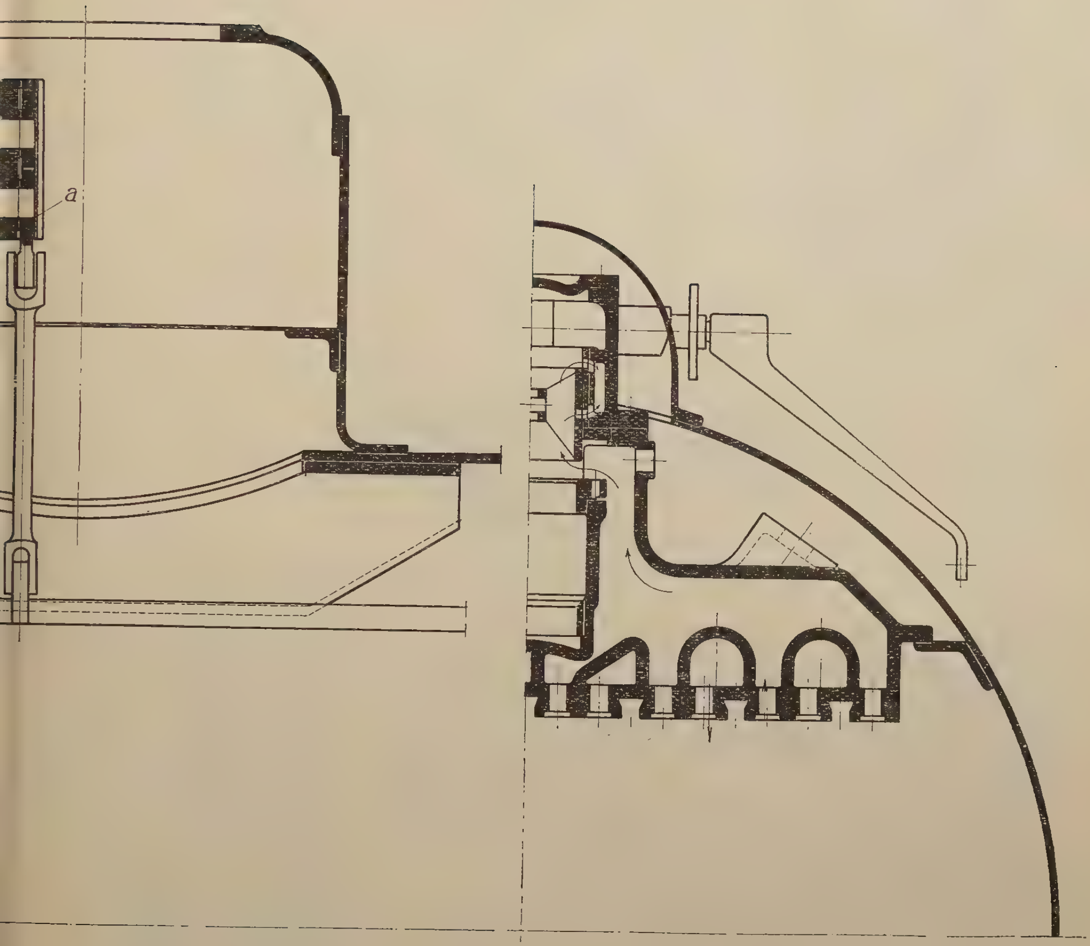


Fig. 27. — Regulator between s

The valve placed in the dome is normally open, the regulator proper being placed above the superheater header. The valve in the dome is only a safety device to shut off the steam in the regulator. When the regulator is closed, steam circulates through the superheater and the double steam pipe connecting the valve in the dome with the regulator is shown at the arrows in figure 27. In opening the regulator B the return passages in the dome are closed by means of the valve C and the steam flows directly from the superheater towards the steam pipes in the or-



ylinders (Bergslagen Railway).

dinary way. The operation of regulators of this type appears to be satisfactory.

### E. — Steam driers on superheated locomotives.

Apart from the Belgian National Railway Company which has experimented with such devices without taking any further action, no other administration has done so.

### F. — Tube cleaners.

From the information received it appears that only a few administrations use

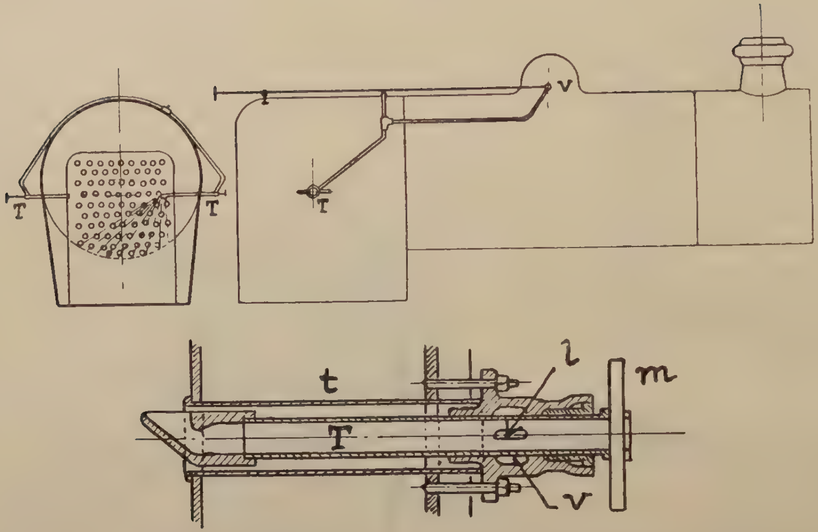


Fig. 28. — « Superior » system tube cleaner (Belgian National Railway Company).

fittings for cleaning out the tubes while running. Tubes are cleaned at the sheds (in addition to rodding which is still carried out) by means of steam or compressed air.

a) *Steam tube cleaners.*

Most frequently the blower is a simple iron tube applied successively to the end of each tube which is cleaned by a jet of steam. The operation which otherwise gives satisfactory results takes a long time and is relatively costly on account of the considerable amount of steam used. The union from which steam is taken is generally placed on the carriage warming pipe or on the injector, and the tube-cleaner is connected up by a flexible metallic pipe.

A device for cleaning tubes while running is employed on the Belgian National Railway Company and the Polish Railways' engines. This is the *Superior* type blower which gives good results. The apparatus is shown in figure 28 and consists of a pair of nozzles T on either side of the engine, placed on the side walls of the firebox in hollow tubes which replace stays between the firebox plates. The nozzle T slides in the tube *t* and in accordance with the position occupied cover or uncover the orifices *l*, the cavity *v* is supplied with steam by a steam pipe from a valve B. The hand wheel *m* allows the nozzle T to be introduced or withdrawn and also gives it a rotary movement. To clean the tubes one opens the superheater dampers where fitted, the steam supply and the blower, and after having closed the firebox door forces the nozzle T to its extreme position, steam issuing from the orifice and the nozzle which is controlled apart from the hand wheel *m* impinges on one half of the tubeplate, the jets of steam blowing the soot through the tubes towards the chimney. This operation is continued for 2 or 3 minutes until the steam issuing from the chimney is no longer black, this operation is repeated on the opposite to clean the other

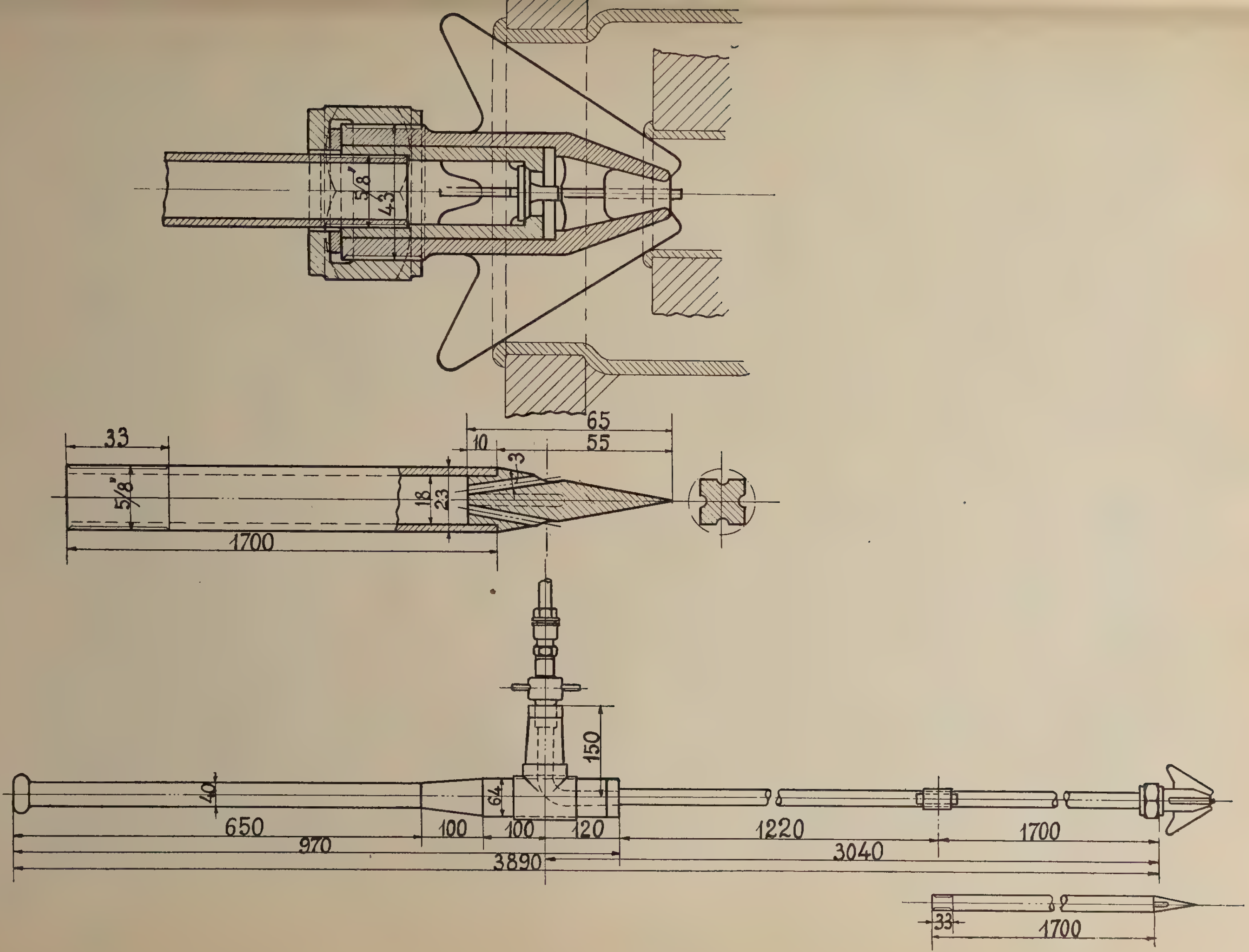


Fig. 28*bis*. — Tube cleaner.

half of the tubes. By repeating this operation several times during the running, the tubes are almost perfectly clean when re-entering the shed.

### b) *Tube cleaning by compressed air.*

Tubes may be blown out by a simple pipe applied successively to the tubes, as in the case of steam jets. The advantage of the latter method is that it causes no danger to the staff but has the disadvantage of cooling the tubes. The Czecho-Slovakian Railways employ the Fraissinet apparatus which uses compressed air from the main reservoir on a locomotive or from a shed supply. This apparatus is simple and gives satisfactory results. The process usually takes to 20 to 30 minutes. It is to be noted that the amount of air used is considerable and that single phase pumps on the engines cannot maintain the pressure in the main reservoir during the operation which has to be interrupted from time to time to re-create the necessary pressure. Two-phase pumps which are coming into extended use allow the pressure in the reservoir to be maintained.

### c) *Tube cleaning by induced draught.*

The Czecho-Slovakian Railways also use the Haczewski apparatus for cleaning tubes, this being based on the ejector principle. Besides the device described, other systems have been tried on various administrations without, however, their use being made general. Thus we may mention the *Diamond* blower in Norway, and the *Parry* soot blower in Holland.

The Egyptian State Railways are also experimenting with soot blowers in the side of the firebox.

## G. — **Boosters.**

No administration concerned uses a booster on its locomotives.

## H. — **Use of special steels.**

The components for which special steels are used are as follows :

### a) *Crank axles.*

*Czecho-Slovakian Railways :* Martin steel with at least 3 % nickel.

*Belgian National Railway Company :* Steel with 3 % nickel, and 0.25 % chromium. Minimum tensile : 60 kgr. per square mm. (38.1 Engl. tons per sq. inch). Minimum elongation : 18 % on a length of 200 mm. (7 7/8 inches); reduction in area 45 % minimum on a test piece 20 mm. (25/32 inch) diameter. The test piece to be taken in a longitudinal position along the axle from a test piece provided at one end.

The deficiency in tensile strength may be compensated by an increase in elongation at the rate of 1 1/2 % elongation for every reduction of 1 kgr. (0.635 Engl. ton per sq. inch) in tensile strength up to a maximum of 2 kgr. (1.270 Engl. tons per sq. inch) tensile strength being compensated by 3 % tensile elongation.

*Bulgarian State :* Nickel crucible steel, 5 to 7 % nickel. Minimum tensile 60 kgr. per mm$^2$ (38.1 Engl. tons per sq. inch). Minimum elongation 18 % on a length of 200 mm. (7 7/8 inches).

*Rumanian State :* Nickel steel 5 % maximum. Minimum tensile 60 kgr. per mm$^2$ (38.1 English tons per sq. inch). Elongation 18 % on a length of 200 mm. (7 7/8 inches).

*Norwegian State:* Nickel steel 3 % (formerly 5 %).

*Swedish State :* Nickel steel 3 % minimum, or manganese steel. Minimum tensile 55 kgr. per mm² (34.9 Engl. tons per sq. inch). Minimum elongation 20 %.

*Bergslagen Railway :* Manufacturer is at liberty to choose between heat treated Martin steel and nickel steel. Tensile 50-60 kgr. per mm² (34.9 to 38.1 Engl. tons per sq. inch). Elastic limit at least 35 kgr. per mm² (22.2 Engl. tons per sq. inch). Elongation 20 to 17 %. Length between gauge marks 50 mm. (1 31/32 inches), reduction in area 30 %.

### b) *Crank pins.*

*Swedish State Railways :* Nickel steel or chrome steel, 3 % nickel minimum. Tensile 90 to 100 kgr. per mm² (57.1 to 63.5 Engl. tons per sq. inch). Minimum elongation 10 % on a length between gauge marks $= 11.3 \sqrt{S}$.

*Bergslagen Railway :* Nickel or chrome nickel steel. Minimum tensile 90 kgr. per mm² (57.1 Engl. tons per sq. inch). Minimum elongation 12 % on 50 mm. (1 31/32 inches).

*Finnish State :* Chrome nickel steel. Tensile 90 to 100 kgr. per mm² (57.1 to 63.5 Engl. tons per sq. inch). Elongation 10 % on 100 mm. (3 15/16 inches). Impact test on bar 30 mm. (1 3/16 inches), square, 160 mm. (6 5/16 inches long, distance between supports 120 mm. (4 3/4 inches) with a semi-circular notch 4 mm. (5/32 inch) diameter; at least 12 Kg.-M. per cm² (560 foot-pounds per sq. inch).

### c) *Connecting rods.*

*Czecho-Slovakian State :* Only for rods having a length greater than 3 metres (9 ft. 10 1/8 in.), cast steel of 55 to 65 kgr. per mm² (34.9 to 41.3 Engl. tons per sq. inch) tensile.

### d) *Piston rods.*

*Netherlands Railways.* No data.

*Bulgarian State :* Siemens Martin steel, 50 to 60 kgr. per mm² (31.7 to 38.1 Engl. tons per sq. inch) tensile. Minimum elongation 20 %.

### e) *Bar frames.*

*Czecho-Slovakian State :* Vanadium steel.

### f) *Draw gear.*

*Czecho-Slovakian State :* Screws, steel 75 to 90 kgr. per mm² (47.6 to 57.1 Engl. tons per sq. inch) tensile. Drawpin and main drawbar, 70 to 85 kgr. per mm² (44.4 to 54 Engl. tons per sq. inch) steel. Nuts, hooks and links, 60 to 70 kgr. per mm² (38.1 to 44.4 Engl. tons per sq. inch) steel.

## I. — **Use of special light alloys.**

The only test made in this direction with a view to reducing the weight of certain parts of locomotives have been carried out by the Czecho-Slovakian State Railways who have fitted some engines experimentally with valves and pistons of aluminium. The results obtained are not encouraging.

## J. — **Lighting of locomotives.**

Improvements have been widely carried out with the lighting of locomotives, and oil lamps which have so long been used as the only means of illumination, and which are still used, are in many cases replaced to-day by more modern systems. As regards the engine headlamps, points of view differ, certain administrations intend these to light up the track, while others merely regard them as signals which should be easily visible from a distance but which need not be sufficiently strong to light up the track from the footplate at the risk of dazzling the enginemen on trains proceeding in the opposite direction. Both gas and electricity are used by the various administrations consulted.

### a) *Gas lighting (acetylene).*

Lamps may themselves produce acetylene or they may be supplied by a special generator. The Czecho-Slovakian Railways use lamps of the *Speci Cerny* type which may be used either for paraffin, acetylene or electricity.

In Sweden, Denmark and Finland, the *Aga dissolved acetylene system* is widely used. In this system the gas is dissolved in acetone and compressed in a steel vessel which serves as an accumulator. This container is carried on the locomotive and when the pressure has fallen to 1.5 atmospheres (22 lb. per square inch) it is merely replaced by a full container. As in the case of an electric accumulator, the headlight is very powerful.

In Norway, this system has also been tried, but electric light is more widely used in this country.

### b) *Electric lighting.*

Numerous systems of electric lighting, especially by turbo-generators, have been adopted or tested on the Railways concerned. In Czecho-Slovakia the *Brown-Boveri, Kunhert, Westinghouse, Sunbeam* and *A. E. G.* have been tested. The capacity of the dynamo used varies from about 350 to 500 watts at voltages varying from 24 to 35. The weight of the turbo-generator is from 60 to 100 kgr. (132 to 220 lb.) and steam consumption ranges from 36 to 52 kgr. (79.4 to 114.6 lb.) per hour. Maintenance costs are very low, especially it would appear, with the *Kunhert* and *Sunbeam systems*. All these electric systems allow the motion to be inspected during the night under very favourable conditions, as plugs are provided along the engine side to which portable hand lamps can be connected for this purpose. No decision has yet been made as to which system to adopt as standard, and the trials are continuing.

In Norway the *Sunbeam* and the *Pyle National* headlights and turbo-generators are used. The maintenance costs of these two systems are stated to be very low, and both appear to meet service requirements.

Tests have also been made on the Guillaume-Luxembourg with lighting by means of a turbo-generator.

In Sweden, the *Svenska Accumulator A. B. Jungner* system is used. This consist of two batteries of accumulators carried on the engine, with a total capacity of 200 ampere-hours, giving a current of 9.5 amperes at 6 volts.

In Rumania electric lighting is also being experimented with, and the *Bosch* system has been applied to three 4-6-2 locomotives. This system consists of a dynamo carried on the bogie and driven from the leading axle by means of a pulley and an accumulator battery. The dynamo provides current for the lamps and charges the accumulators whenever the speed of the engine exceeds 30 km. (18.6 miles) per hour. Below this speed the battery comes into action. The apparatus works well if the engine runs above 30 km. (18.6 miles) per hour sufficiently to recharge the accumulators. The trial is of too short a duration to be able to draw any conclusions.

The Rumanian Railways have also fitted three 4-6-2 locomotives with turbo generators of the *Bruenner Maschinenfabrik* type with the object of lighting the

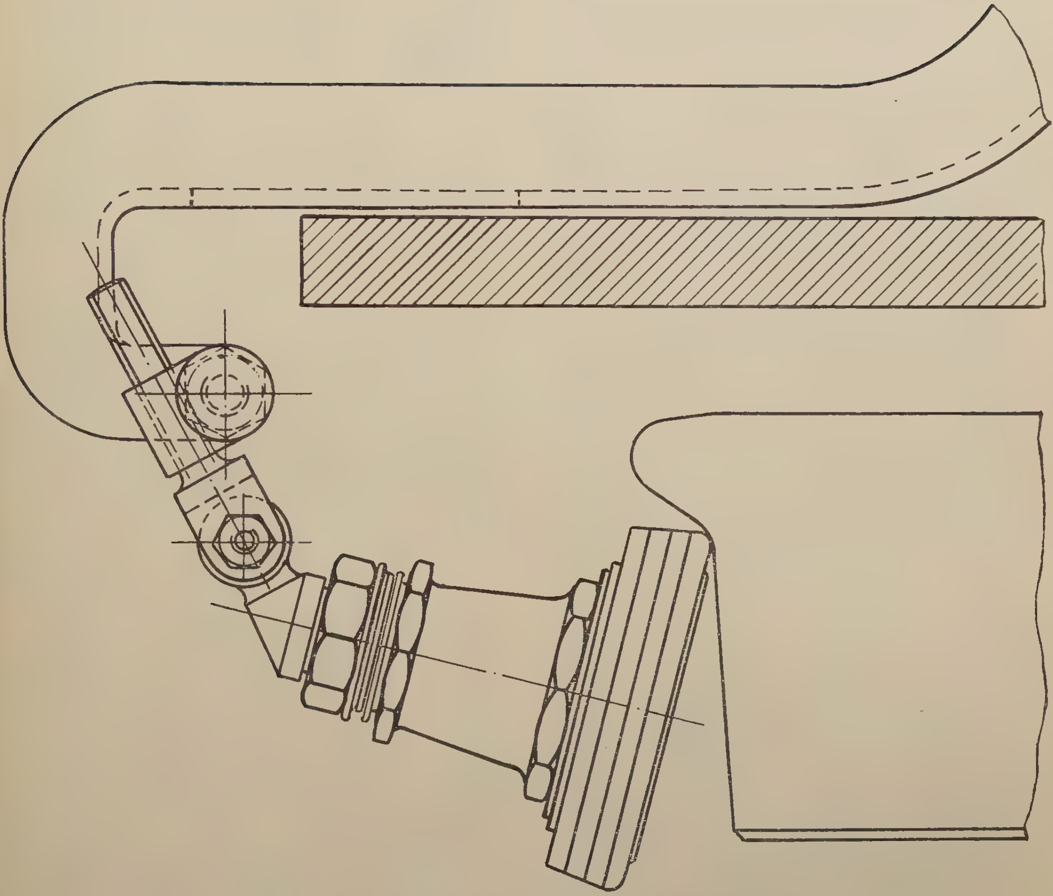


Fig. 29. — Buclon flange lubricator, Guillaume-Luxembourg (Alsace-Lorraine).

whole of the train of 10 to 12 eight-wheel vehicles, including the locomotive. For this reason the turbo-generator is fairly powerful, 5 kw. at 55 volts. This installation is also of recent date.

In Denmark Messrs *Henschel & Sohn's* system is being tried.

### K. — Lubrication of flanges.

Different systems are employed by the various administrations for lubricating the flanges of engines used on lines abounding in curves. Some of these are very simple; thus the Rumanian Railways use an arrangement consisting of a pipe from the exhaust to the Westinghouse pump which discharges against the flanges of the leading wheels steam containing a certain amount of oil. In other cases a rectangular tube is pressed against the flange by means of a spring, this being filled with a thick grease. A similar system is in use on the Czecho-Slovakian Railways.

The Polish Railways use pipes from

the end of the steam chest which carry to the flanges of the wheels the grease which runs in drops.

On the Guillaume-Luxembourg, tests have recently been made with a Buclon lubricator which consists of a rotating disc soaked in oil turning in contact with the flange. Inside this disc is an oil reservoir (special oil maintaining its fluidity at different temperatures which keeps the disc constantly oily).

The Belgian National Railway Company and the Swiss Federal Railways are also carrying out tests with various apparatus but their applications are too recent to give any definite information on their efficiency. Moreover, opinions are divided as the advantages obtained by the devices.

### L. — **Balancing of locomotives.**

#### 1. — *Balancing of reciprocating masses.*

All the administrations concerned balance these masses in such a way as not to produce a variation of the load on the rail greater than 15 % of the static load, when the engine is running at its maximum speed. On two-cylinder locomotives the proportion balanced varies from 15 to 60 % of reciprocating masses (the proportion being increased when the ratio of the wheelbase of the locomotive to its length is smaller. On four-cylinder locomotives in which the reciprocating masses balance each other, no balance weights are necessary.

#### 2. — *Methods of checking the balancing of coupled axles.*

None of the Administrations concerned possess special apparatus for checking the balancing of coupled axles, this being generally left to the builder.

On the Swiss Federal Railways, the wheels and axles are, however, balanced statically.

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## FINAL SUMMARY.

### CHAPTER I.

### Increased boiler pressure.

For boilers of the orthodox locomotive type there is not, generally speaking, any tendency to raise the pressure above the usual present day maximum, that is to say, 14 kgr. (200 lb. per square inch) for simple engines, and 16 kgr. (227 lb. per square inch) for compounds.

### CHAPTER II.

### Superheating.

*a*) The superheater engines of the majority of the administrations concerned superheat the steam to a temperature of 325 to 350° C. (620 to 665° F.); some engines attain 370° C. (700° F.) when working heavily;

*b*) There is a tendency to increase present day temperatures in order to obtain the maximum fuel economy within the limits imposed by the efficient lubrication of the parts in contact with the steam. It would appear that the limit is now in the region of 380° C. (720° F.);

*c*) In fixing the dimensions of superheaters, consideration should be given to the ratio of the resistances offered to the passage of the gases by the evaporative tubes and superheater flues respectively;

*d*) In general, superheaters with large tubes are preferred, however, a number of administrations have also adopted superheaters in tubes of small diameter and state that these are satisfactory and that no serious difficulty has been experienced in keeping the tubes clean. In superheaters with large tubes, dampers have generally been abandoned, and in some cases a large air valve is mounted on the header. Some administrations, however, consider that the dampers are necessary and continue to use them;

*e*) It does not seem necessary to have a pyrometer on a locomotive;

*f*) Lubrication of cylinders and valves is effected on the majority of railways by mechanical lubricators. Tests which seems to promise favourable results are in hand with emulsified oil;

*g*) The use of piston valves with narrow rings is almost universal. Metallic packing is used for piston rods and valve spindles;

*h*) The use both of air valves and of by-pass valves is very general.

## CHAPTER III.

### Feed water heating.

The majority of the administrations obtain good results from the use of feed water heaters using part of the exhaust. The exhaust steam injector is widely used and is cheap to maintain while giving a satisfactory economy. Surface feed water heaters are widely used on the railways dealt with in this report. In practice, neither the draught nor the degree of superheat appear to be affected by the use of feed water heaters, and the amount of oil introduced into the boiler is negligible.

## CHAPTER IV.

### Air pre-heating.

No ordinary locomotives have up to the present been fitted with air pre-heaters.

## CHAPTER V.

### Valve gear.

*a*) The Walschaerts (Heusinger) type of gear is the most widely used;

*b*) The practice of driving more than one valve from each set of gear is widely adopted, and certain administrations propose to extend it. However, independent gears are generally preferred in spite of the higher first cost and maintenance charges involved;

*c*) Limited cut off gears are not used;

*d*) A number of administrations have tried poppet valve gears; the Lentz system appears to give promising results, but is still in the experimental stage. This question appears to be of interest.

## CHAPTER VI.

### Smokebox and blast pipe.

*a* ) The fixed blast pipe nozzle is widely used and gives satisfactory results;

*b*) Multiple exhausts have been adopted by certain administrations, especially for powerful engines;

*c*) Various systems have been tried for improving the draught, some of these giving encouraging results. Reduction in the amount of sparks thrown is a point to be considered;

*d*) A number of administrations have carried out tests with devices intended to lift the smoke.

It appears desirable to follow up this question in view of the danger resulting from the driver's view being obscured by smoke.

## CHAPTER VII.

## Other improvements to reciprocating locomotives.

### A. — Compounding.

Many administrations do not consider the advantages of compounding superheater locomotives sufficient to justify their use. In every case this method only appears to be applied to powerful engines with four cylinders.

### B. — Improvement of combustion.

*a*) The railways dealt with in this report do not use combustion chambers or special grates;

*b*) Encouraging tests have been made with the « Langer combustion control ». It is stated that there is a saving in coal.

### C. — Devices intended to improve the circulation of water.

Trials have been carried out by a number of administrations with water tubes through the firebox, supporting the brick-arch. Results are not as yet sufficiently definite.

### D. — Regulators.

*a*) Regulators with mushroom valves are widely used;

*b*) Regulators placed between the superheater and the cylinders appear to be advantageous for shunting engines. However, few have been fitted up to the present.

### E. — Steam driers on superheater locomotives.

These are not used by the administrations concerned.

### F. — Tube cleaners.

*a*) The use of steam or compressed air for cleaning tubes at the sheds is general;

*b*) Fittings whereby the tubes can be blown through while running are used by some of the administrations and give good results.

### G. — Boosters.

None of the administrations concerned have fitted these.

### H. — Special steels.

The use of these steels is at present limited to crank axles, crankpins and motion parts, as well as bar frames of heavy engines.

### I. — Special light weight alloys.

The use of alloys of this nature has not been developed.

### J. — Lighting of locomotives.

*a*) There is a tendency to improve the lighting on locomotives, and the use of acetylene or especially electricity (with turbo-generator) has greatly extended;

*b*) The intensity of engine head lights differs widely on various administrations according to the point of view adopted (for lighting up a track or merely as signals).

### K. — Lubrication of flanges.

A number of administrations lubricate the flanges of the leading coupled wheels, especially on those used on lines with numerous curves of small radius. It appears desirable to obtain exact information on the advantages gained.

### L. — Balancing of locomotives.

None of the administrations concerned possess special machines for checking the balancing of the coupled axles, the balance weight merely being calculated. This practice appears to cause no trouble.

# APPENDICES.

## Superheaters

| ADMINISTRATION. | Type of locomotive. | Total heating surface. C Square metres. | Super-heater heating surface. Σ Square metres. | $\frac{\Sigma}{C}$ | Total free area through evaporative tubes $S_B$ Square metres. | Total free area through super-heater flues $S_S$ Square metres | $\frac{S_S}{S_B}$ |
|---|---|---|---|---|---|---|---|
| Belgian National Railway Company. | Type 7. Compound . . . . | 159.96 | 54.83 | 0.343 | 0.245 | 0.217 | 0.88 |
| | — 33. „ . . . . . . | 179.30 | 59.50 | 0.332 | 0.277 | 0.217 | 0.7 |
| | — 38. Simple expansion . . | 169 70 | 56.10 | 0.330 | 0.254 | 0.222 | 0.87 |
| | — 10. Simple exp. . . . . *Original.* | 240.00 | 62.00 | 0.257 | 0 336 | 0.226 | 0.61 |
| | — 10. Modified . . . . . | 232.73 | 85.53 | 0.367 | 0 302 | 0 309 | 1.0 |
| | — 36. Simple exp. . . . . *Original.* | 238.95 | 62.00 | 0.260 | 0.366 | 0.226 | 0.61 |
| | -- 36. Modified . . . . . | 231.68 | 85.53 | 0.369 | 0.302 | 0.309 | 1.0 |
| Swedish State. | Litt. B. Simple expansion . . . | 145 60 | 47 00 | 0.322 | 0 212 | 0.198 | 0.9 |
| | — F. Compound original . . | 189.30 | 66.00 | 0 348 | 0 267 | 0.191 | 0.7 |
| | — F. Compound modified . . | 190.30 | 62.70 | 0.330 | 0.267 | 0.217 | 0.8 |
| | — C. Simple exp. . . . . | 145.60 | 47.00 | 0.322 | 0 212 | 0.198 | 0.9 |
| | — Sa Simple exp. original . . | 87.40 | 23.00 | 0.263 | 0.164 | 0.114 | 0.6 |
| | — Sa Simple exp. modified . . | 86.50 | 27.50 | 0.318 | 0.148 | 0.137 | 0.9 |
| Danish State. | R II. Simple expansion . . . | 152.00 | 51.00 | 0.336 | 0.216 | 0.229 | 1 |
| Polish State. | OK. 22. Simple expansion . . | 182 10 | 61.60 | 0.338 | 0 278 | 0.203 | 0.7 |
| | Os. 24. — . . | 199.50 | 75.50 | 0.378 | 0 256 | 0.252 | 0.9 |
| | Tr. 12. — . . | 166.70 | 38 30 | 0 230 | 0.287 | 0 188 | 0 6 |
| | Tr. 21. — . . | 191.00 | 59.00 | 0 309 | 0.280 | 0 195 | 0.6 |
| | Ty. 23 — . . | 223 90 | 73 50 | 0.329 | 0 317 | 0 247 | 0.7 |

## ing locomotives.

APPENDIX I.

| esistance of tubes to gases. | | $\frac{R_S}{R_B}$ | Number and diameter of tubes. | | $\frac{N_B}{N_S}$ | Temperature of superheat obtained in degrees centigrade. | *REMARKS.* |
|---|---|---|---|---|---|---|---|
| porative $\times 10^{-4}$ | Superheater $R_S \times 10^{-4}$ | | Evaporative $N_B$ | Superheater. $N_S$ | | | |
| 00.0 | 95.5 | 0.295 | 154 (45/50) | 28 (125/133) | 5.5 | 350-370 | Maximum temperature in high pressure steam chest. |
| 89.3 | 30.2 | 0.338 | 174 „ | 28 „ | 6.2 | 350 | |
| 00.7 | 25.6 | 0.254 | 160 „ | 26 (129/137) | 6.15 | 350 | |
| 75.2 | 32.9 | 0.438 | 230 „ | 31 (118/127) | 7.4 | 300 | Engines of types 10 and 36 as modified show an economy of fuel of 22 to 25 °/₀ compared with engines not modified. |
| 90.9 | 23.5 | 0.258 | 190 „ | 40 (125/133) | 4.75 | 350 | |
| 75.2 | 32.9 | 0.438 | 230 „ | 31 (118/127) | 7.4 | 300 | |
| 90.9 | 23.5 | 0.258 | 190 „ | 40 (125/133) | 4.75 | 350 | |
| 26.0 | 33.5 | 0.266 | 136 (44.5/50) | 26 (122/131) | 5.2 | 330 | At header. |
| 98.5 | 52.7 | 0.535 | 154 (47/52) | 28 „ | 5.5 | 310 | |
| 98.5 | 35.7 | 0.363 | 154 „ | 28 (125/133) | 5.5 | 335 | |
| 26.0 | 33.5 | 0.266 | 136 (44.5/50) | 26 (122/131) | 5.2 | — | |
| 48.0 | 50.5 | 0.340 | 101 „ | 15 „ | 6.7 | 325 | |
| 64.0 | 42.2 | 0.257 | 91 „ | 18 „ | 5.05 | ... | |
| ... | ... | ... | 133 (45.5/51) | 28 (125/133 | 4.75 | ... | ... |
| | | | | | | At header. | |
| 94.6 | 39.5 | 0.418 | 175 (45/50) | 28 (125/133) | 6.25 | ... | ... |
| 14.0 | 30.7 | 0.270 | 161 „ | 32 „ | 5.0 | 320 | 300° C. in steam chests. |
| ... | ... | ... | 173 (46/51) | 24 „ | 7.2 | 270 | 210° „ „ „ |
| 98.2 | 49.2 | 0.500 | 176 (45/50) | 40 „ | 4.4 | 320 | 250° „ „ „ |
| 88.0 | 39.7 | 0.497 | 199 „ | 40 „ | 4.95 | 316 | 260° „ „ „ |

## Superheaters

| ADMINISTRATION. | Type of locomotive. | Total heating surface. C<br>Square metres. | Super-heater heating surface. Σ<br>Square metres | $\frac{\Sigma}{C}$ | Total free area through evaporative tubes $S_B$<br>Square metres. | Total free area through super-heater flues $S_S$<br>Square metres | $\frac{S}{S}$ |
|---|---|---|---|---|---|---|---|
| Czecho-Slovakian State. | 387.0 Simple expansion . . . | 260.00 | 93 00 | 0 354 | 0.0881 | 0.3219 | 3. |
| | 386.0 — . . . | 246.90 | 89.30 | 0.361 | 0.0681 | 0 3099 | 4. |
| | 365.0 — . . . | 214.72 | 55.65 | 0.259 | 0.2675 | 0.2381 | 0. |
| | 354 1 — . . . | 129.60 | 59 70 | 0.460 | 0.0349 | 0.1964 | 5. |
| | 445.1 — . . . | 215.65 | 55.65 | 0.481 | 0.2675 | 0.2381 | 0. |
| | 446.0 — . . . | 217.10 | 82.88 | 0 386 | 0.1230 | 0.2300 | 1. |
| | 423.0 — . . . | 122.60 | 35 24 | 0.289 | 0.0831 | 0.1450 | 1. |
| | 524.1 — . . . | 154.50 | 68.80 | 0.445 | 0.0498 | 0.2243 | 4 |
| | 534.0 — . . . | 221.00 | 93.20 | 0.422 | 0.0548 | 0 3052 | 5. |
| | 354.6 (modified) . . . . | 129.85 | 45.73 | 0.352 | 0.0349 | 0.1964 | 5 |
| | 434.2 — . . . . | 162.90 | 77.30 | 0.474 | 0.0316 | 0.2243 | 7. |
| | 524 2 — . . . . | 144.20 | 54 70 | 0.379 | 0.0316 | 0.2243 | 7. |
| Rumanian State. | 230 Simple expansion . . . . | 144.07 | 58.90 | 0.410 | 0.195 | 0.140 | 0.7 |
| | 231 — . . . | 251 20 | 60.60 | 0.237 | 0.384 | 0.221 | 0 5 |

Formulæ used for calcula

For one tube (plain) : $r_B = 10^{15}\frac{\pi D_B l}{\frac{\left(\pi D_B^2\right)^3}{4}}$; For one superheater

Per set of tubes : $\frac{1}{R} = \Sigma\left(\frac{1}{r}\right)$. The fig

| Resistance of tubes to gases. | | $\frac{R_S}{R_B}$ | Number and diameter of tubes. | | $\frac{N_B}{N_S}$ | Temperature of superheat obtained in degrees centigrade. | *REMARKS.* |
|---|---|---|---|---|---|---|---|
| Evaporative $R_B \times 10^{-4}$ | Superheater $R_S \times 10^{-4}$ | | Evaporative $N_B$ | Superheater. $N_S$ | | | |
| 195.2 | 127.5 | 0.653 | 53 | 158 | 0.34 | At least 325. | Schmidt superheater with small tubes (70/76 mm). |
| 252.2 | 132.4 | 0.525 | 41 | 152 | 0.27 | | Schmidt superheater with small tubes. |
| 64.2 | 19.45 | 0.303 | 161 | 30 (126/133) | 5.4 | | Schmidt superheater with large flues. |
| 422.0 | 179.6 | 0.381 | 21 | 96 | 0.22 | | Schmidt superheater with small tubes. |
| 64.2 | 19.45 | 0.303 | 161 | 30 | 5.4 | | Schmidt superheater with large flues. |
| 139.7 | 180.0 | 1.29 | 74 | 112 | 0.66 | | |
| 177.5 | 239.5 | 1.35 | 50 | 72 | 0.70 | | Superheater with small tubes. |
| 296.0 | 156.8 | 0.53 | 30 | 110 | 0.27 | | Engines converted from saturated compound to simple superheater. Coal economy obtained : 9 to 10 %. |
| 323.4 | 127.7 | 0.395 | 33 | 150 | 0.22 | | |
| 415.0 | 175.5 | 0.423 | 21 | 96 | 0.22 | | |
| 520.0 | 174.0 | 0.335 | 46 | 110 | 0.42 | | |
| 466.0 | 156.8 | 0.3296 | 46 | 110 | 0.42 | | |
| 83.8 | 26.5 | 0.316 | 123 (45/50) | 26 (125/133) | 4.72 | 280-300 | ... |
| 42.5 | 18.1 | 0.425 | 223 (47/52) | 27 (125/133) | 8.25 | | |

he resistance to gases :

ontaining a four-pipe element : $r_s = 10^{15} \times \frac{(\pi D_s + 4\pi d_s)\,l}{\frac{\left[\pi\left(D_s^2 - 4d_s^2\right)\right]^3}{4}}$.

uoted represent $R_B$ or $R_S \times 10^{-4}$.

## Table of lubricating oils

| ADMINISTRATION. | **Belgian National Railway Company.** | **Swiss Federal Railways.** | **Swedish State.** | **Czecho-Slovakian State.** | | **Polish State.** | |
|---|---|---|---|---|---|---|---|
| Name of oil used . . . | Cylindrine. | Superheater oil. | Superheater oil. | American cylinder oil from the Oil Trading Co. | Pennsylvania cylinder oil from Messrs Ostia. | American oil. | Polis oil. |
| Class of engines for which used. | All engines. | ... | ... | ... | ... | For express and long distance passenger. | For le import truffic |
| Class of oil . . . . . . | Mineral oil containing 5 % as a maximum or 3.5 % minimum saponifiable oil. The determination of the saponifiable content is based on an index of saponification equal to 190. | Mineral oil absolutely pure from mechanical impurities and water, dark brown colour. | Pure mineral oil, dark brown colour. | Pure mineral oil, dark greenish brown colour. | Pure mineral oil, dark brown colour. | ... | ... |
| Density at 15°C. . . . . | About 0.900. | 0.906 | ... | 0.909-0.910 | 0.904-0.906 | 0.900-0.920 | 0.960 |
| Flash point : | | | | | | | |
| *a*) In open vessel (Marcusson test); | ... | 290°C. | 320°C minimum. | 305°C-307°C without correction. | 301°C-303 C without correction. | 310°C. | 280°C. |
| *b*) In closed vessel (Pensky-Martens test). | Below 255°C. | ... | ... | ... | ... | ... | ... |

## perheater locomotives.

APPENDIX II.

| rwegian State. | Bergslagen. Railway. | Finnish State. | Guillaume-Luxembourg (Alsace-Lorraine). | Rumanian State. | S. H. S. State. | Prince-Henry. | Bulgarian State. | Danish State. |
|---|---|---|---|---|---|---|---|---|
| erheater oil. | Superheater oil. | Superheater oil. | Superheater oil | Superheater oil. | Superheater oil. | Superheater oil. | . . | Superheater oil. |
| ... | ... | ... | . . | ... | ... | ... | ... | ... |
| ... | ... | Pure filtered mineral oil, fluidity at + 15°C., free from water, acids or alkalies. | ... | Pure mineral oil without acids or free alkalies. | ... | ... | Pure refined mineral oil, brownish green, brown or greenish. | Straight mineral oil. |
| 00-0.910 | 0.890-0.940 | ... | 0.90017 | 0.950 | 0.890-0.945 | 0.902-0.907 | 0 915-0.950 | 0.91-0.92 |
| 5°C minimum. | ... | 320°C minimum. | ... | 310°C. | 310°C minimum. | 295°C-310°C. | 300°C minimum. | 320°C. |
| 5°C minimum. | 260°C minimum. | ... | 270°C. | ... | ... | ... | ... | ... |

## Table of lubricating oils

| Administration. | Belgian National Railway Company. | Swiss Federal Railways. | Swedish State. | Czecho-Slovakian State. | | Polish State. | |
|---|---|---|---|---|---|---|---|
| Ignition point. . . . | .. | 355°C. | ... | ... | ... | ... | . |
| Viscosity (Engler). at 50°C . | | 46.0 | ... | 50.0 | 56.0 | ... | . |
| at 75°C . | 12.5 maximum. | ... | ... | ... | ... | ... | . |
| at 100°C . | | 5.8 | 7.5 minimum. | 5.4-5.6 | 5.5-5.7 | 5.0-6.0 | 3.0 |
| at 150°C . | 1.95 minimum. | ... | ... | ... | ... | ... | . |
| at 250°C . | | 1.75 | ... | ... | ... | ... | . |
| Fluidity (Barbey) . . . | ... | ... | ... | ... | ... | ... | . |
| Asphalt. . . . . . . . | ... | ... | ... | Below 0.02 %. | Below 0.03 %. | ... | . |
| Ash . . . . . . . . . . | ... | 0.1 % maximum. | ... | ... | ... | ... | . |
| Acidity (expressed as $SO_3$). | ... | 0.012 %. | ... | 0.015 % | 0.02 % maximum. | ... | . |
| Other special clauses . . | See report. | ... | ... | Traces of asphalt matter. | ... | Tar residue 2 % maximum. | Tar r<br>2 |

uperheater locomotives (*continued*). APPENDIX II (*continued*).

| orvegian State. | Bergslagen Railway. | Finnish State. | Guillaume-Luxembourg (Alsace Lorraine). | Rumanian State. | S. H. S. State | Prince-Henry Railway. | Bulgarian State. | Danish State. |
|---|---|---|---|---|---|---|---|---|
| ... | ... | ... | 325°C. | ... | ... | ... | ... | ... |
| ... | ... | ... | 27.42 | ... | ... | ... | ... | 70 |
| ... | .. | ... | ... | ... | ... | ... | ... | ... |
| .. | 4.4-6.8 | 5.5 minimum. | 4.00 | 5.0-7.0 | 5.0 minimum. | 4.5-6.0 | 5.0-7.0 | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | .. | ... | ... |
| ... | ... | ... | at 50°C-24.<br>at 100°C-176. | ... | ... | ... | ... | ... |
| Traces. | ... | 0.15 % maximum. | 0.204 % | 0.1 % | ... | ... | 0.1 % | ... |
| ... | ... | ... | 0.013 % | 0.1 % | ... | ... | ... | ... |
| ... | 0.03 % | 0.05 % maximum. | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | Water 0.2 %. | Insoluble matter : 0.1 % maximum. | ... | ... | ... |

Locomot

| ADMINISTRATION | Czecho-Slovakian State Railways. | | Swiss Federal Railways. | |
|---|---|---|---|---|
| CLASS OF ENGINE | 387.0 | 534.0 | A 3/5 | C 5/6 |
| With or without superheater | With superheater. | With superheater. | With superheater. | With superheat |
| Simple or compound | Simple expansion. | Simple expansion. | Compound. | Compound. |
| Grate area, in square metres | 4.8 | 4.20 | 2.8 | 3.7 |
| Total heating surface, in square metres | 260.0 | 221.0 | 161.6 | 210.1 |
| Superheater surface, in square metres | 93.0 | 93.2 | 42.4 | 63.6 |
| Working pressure, in kilogrammes per cm² | 13 | 14 | 14 | 15 |
| Cylinders : Number and position | 2 outside.<br>1 inside. | 2 outside. | 2 outside.<br>2 inside. | 2 outside.<br>2 inside. |
| HP Diameter, in millimetres | 525 | 620 | 425 | 470 |
| HP Stroke, in millimetres | 680 | 632 | 660 | 640 |
| LP Diameter, in millimetres | ... | ... | 630 | 690 |
| LP Stroke, in millimetres | ... | ... | 660 | 640 |
| Type of valve gear | Heusinger independent. | Heusinger independent. | Walschaerts. | Walschaerts. |
| Section of steam pipe, in square metres | 0.0158 | 0.0201 | 0.008825 | 0.0111 |
| Section of pipe between the H. P. and L. P. cylinders, in square metres. | ... | ... | 0.05089 | 0.06283 |
| Section of blast pipe, in square metres | 0.0227 | 0.0314 | 0.0314 | 0.04155 |

## lve gears.

| Swedish State Railways. | | Bergslagen Railway. | Norwegian State Railways. | | Danish State Railways. |
|---|---|---|---|---|---|
| F | G | H 3 | 30 *b* | 33 *a* | R-II |
| With superheater. | With superheater. | With superheater. | With superheater. | With superheater. | With superheater. |
| Compound. | Simple expansion. | Simple expansion. | Compound. | Simple expansion. | Simple expansion. |
| 3.6 | 2.62 | 3.2 | 2.40 | 2.78 | 2.62 |
| 189.3 | 143.1 | 162.0 | 125.0 | 146.20 | 152.0 |
| 66.0 | 49.5 | 50.0 | 37.0 | 41.80 | 51.0 |
| 13 | 14 | 12 | 13 | 12 | 12 |
| 2 outside.<br>2 inside. | 2 outside. | 2 outside.<br>1 inside. | 2 outside.<br>2 inside. | 2 outside. | 2 outside.<br>1 inside. |
| 420 | 600 | 500 | 390 | 575 | 470 |
| 660 | 660 | 660 | 600 | 640 | 670 |
| 630 | ... | ... | 585 | ... | ... |
| 660 | ... | ... | 600 | ... | ... |
| Walschaerts. | Walschaerts independent. | Walschaerts independent. | Walschaerts conjugated. | Walschaerts conjugated. | ... |
| 0.0153 | 0.0113 | 0.0095 | 0.0113 | 0 0113 | 0.010 |
| 0.0365 | ... | ... | 0.0113 | ... | ... |
| 0.0430 | 0.0226 | 0.0227 | 0 0314 | 0.0284 | 0.011 |

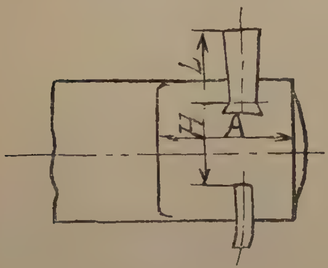
## Locomotive va

| Administration | Czecho-Slovakian State Railways. | | Swiss Federal Railways. | | | |
|---|---|---|---|---|---|---|
| Class of locomotive | 387.0 | 534.0 | A 3/5 | | C 5/6 | |
| Volume of receiver, in cubic decimetres | ... | ... | ... | | .. | |
| Volume of cylinder, in cubic decimetres | 147.2 | 190.8 | HP.<br>93.63 | LP.<br>205.72 | HP.<br>111 | 23 |
| Volume of clearance space in cubic decimetres — Front | 11.8 | 11.2 | ... | .. | ... | . |
| Volume of clearance space in cubic decimetres — Back | 11.9 | 12.7 | ... | ... | ... | . |
| Type of valves (piston or flat) | Piston valves. | Piston valves. | Pist. valv. | Pist. valv. | Pist. valv. | Pist. |
| Diameter of valves, in millimetres | 250 | 280 | 250 | 320 | 250 | 3 |
| Maximum valve travel, in millimetres | 185 | 200 | 177.4 | 185.0 | 165 | 1 |
| Whether inside or outside admission | Inside. | Inside. | Inside. | Outside. | Inside. | Out |
| Steam lap, in millimetres | 40 | 40 | 38 | 38 | Fr 39<br>B. 36 | Fr.<br>B. |
| Exhaust lap, in millimetres | ... | 1 | Fr. — 6<br>B. — 4 | Fr. and<br>B. — 3 | Fr. 6 1/2<br>B. 3 1/2 | Fr.<br>B. - |
| Admission ports — Width in millimetres | 42 | 45 | Fr. 42<br>B. 40 | Fr and<br>B. 45 | 40 | 30 + |
| Admission ports — Developed length in millimetres. | 565 | 630 | ... | ... | ... | . |
| Ratio of diameter of valve to diameter of cylinder. | 0.47 | 0.45 | 0 58 | 0.50 | 0.53 | 0 |
| Ratio of section of steam pipe ($cm^2$) to total heating surface ($m^2$). | 0.61 | 0.91 | 0.54 | | 0.52 | |

| Swedish State Railways. | | | Bergslagen Railway. | Norwegian State Railways. | | | Danish State Railways. |
|---|---|---|---|---|---|---|---|
| F | | G | H 3 | 30 *b* | | 33 *a* | R-II |
| 346 | | ... | ... | 112.7 | | ... | ... |
| HP.<br>96 | LP.<br>205 | 187 | 129.0 | HP.<br>69.68 | BP.<br>161.27 | 166.2 | 116.0 |
| 19.5<br>19.0 | 29.8<br>29.6 | 18.7<br>18 7 | 15.6<br>15.0 | 12.1<br>11.38 | 20.8<br>19.1 | 12.1<br>11.0 | 11 7<br>13.7 |
| on valves. | Piston valves. | Piston valves. | Piston valves. | Piston valves. | Piston valves. | Piston valves. | Piston valves. |
| 280 | 280 | 220 | 250 | 300 | 300 | 220 | 220 |
| 152 | 152 | 187 | 137 | 129.5 | 129.5 | 135 | 177 |
| Inside. | Inside. | Inside. | Inside. | Inside. | Inside. | Inside. | Inside. |
| Fr. 35<br>B. 32.5 | Fr. 33<br>B. 33 | 45 | 30 | Fr. 30.5<br>B. 24 75 | Fr. 24.0<br>B. 26 5 | 31 | 38 |
| Fr. — 3<br>B. 1 | Fr. — 4.5<br>B. — 3 | 5 | — 3 | Fr. — 8.5<br>B. — 0.5 | Fr. 5.0<br>B. — 5.0 | 5 | 2 |
| Fr. 43<br>B. 41.5<br>632 | Fr. 57<br>B. 55<br>632 | 50<br>515 | 45<br>570 | Fr. 26.5<br>B. 29.75<br>780 | Fr. 26.75<br>B. 25.5<br>780 | 2 × 30<br>514 | 52<br>466 |
| 0.66 | 0.44 | 0.36 | 0.50 | 0.76 | 0.51 | 0.38 | 0 46 |
| 0.80 | | 0.78 | 0.58 | 0.89 | | 0.77 | 0.65 |

Smok

| ADMINISTRATION. | Type of engine. | With or without superheater. | Type of superheater. | Grate area. G. | Free area. | | |
|---|---|---|---|---|---|---|---|
| | | | | | Evaporative tubes. | Superheater tubes. | To S |
| | | | | ← square metres | | | |
| *Polish State* . . . . | Ty. 23 (2-10.0) | With. | Schmidt with large flues. | 4.50 | 0.317 | 0.247 | 0.56 |
| *Czecho-Slovakian State* . | 386.0 (4-6-2) with 3 cyl. | With. | Schmidt with small tubes. | 4.57 | 0.0681 | 0.3099 | 0.37 |
| | 534.0 (2.10.0) | With. | | 4 20 | 0 0548 | 0.3052 | 0.36 |
| *Swedish State* . . . | Litt. F. (4-6-2 with 4 cyl.) | With. | Schmidt with large flues. | 3.60 | 0.267 | 0.191<br>0.217 | 0.45<br>0.48 |
| | Litt. G. (0.8.0.) | ... | ... | 2.62 | 0 212 | 0.198 | 0.41 |
| *Norwegian State*. . . | 33.a. | With | Schmidt with large flues. | 2.78 | ... | ... | ... |
| | 30.b. | » | » | 2.40 | ... | ... | ... |
| *Danish State*. . . . | R. II (4-6-0) with 3 eq. c. | With. | Schmidt with large flues. | 2.62 | 0.216 | 0.229 | 0.44 |
| *Rumanian State*. . . | 231 (4-6-2. with 3 eq. c. | With. | Schmidt with large flues. | 4.00 | 0.384 | 0.221 | 0.60 |



## l blast pipe.

Appendix IV.

| atio | Blast pipe orifice. | | Ratio | Chimney. | | | Ratio | H. | A. | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{G}{S}$ | Diameter. | Area $\Omega$ | $\frac{(\Omega\ \text{cm}^2).}{G\ (\text{m}^2).}$ | Minimum diameter. | Minimum cross section. F. | Total height above minimum cross section L. | $\frac{F}{\Omega}$ | | | $\frac{S}{F}$ |
| | metres | sq. metres | | metres | sq. metres | metres | | ← metres → | | |
| .98 | 0.170 | 0.0227 | 50.5 | 0.450<br>and 0.500 | 0.1595<br>0.1970 | 0.870 | 7.00<br>8.65 | 0.945 | 1.900 | 3.53<br>2.86 |
| .08 | 0.170 | 0.0227 | 49.6 | 0.520 | 0.2125 | 0.550 | 9.35 | 1.385 | 2.700 | 1.77 |
| 66 | 0.180 | 0.0254 | 60.6 | 0.530 | 0.2210 | 1.100 | 8.67 | 1.560 | 2.145 | 1.62 |
| .88<br>.45 | 0.140 | 0.0154 | 42.8 | 0.400 | 0.1260 | 0.825 | 8.17 | 0.575 | 2.810 | 3.63<br>3.84 |
| .40 | 0.136 | 0.0146 | 55.6 | 0.420 | 0.1388 | 0.850 | 9.50 | 0.950 | 1.805 | 2.96 |
| ... | 0.140 | 0.0154 | 55.4 | 0.430 | 0.1452 | 0.820 | 9.42 | 1.075 | 1.600 | .. |
| .. | 0.125 | 0.0123 | 51.2 | 0.350 | 0.0962 | about 0.900 | 7.80 | 0.735 | about 2.100 | .. |
| .90 | 0.120 | 0.0113 | 43.0 | 0.425 | 0.1420 | 0.750 | 12.56 | 0.909 | 2.690 | 3.14 |
| .61 | 0.140 | 0.0154 | 36.0 | 0.420 | 0.1388 | 0.800 | 8.98 | 1.009 | 3.234 | 4.38 |

## Statistics giving numbers of simple

| ADMINISTRATION. | 1st January 1922. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Simple engines. | | | | | | Compound engines. | | | | | |
| | Without superheater. | | | With superheater. | | | Without superheater. | | | With superheater. | | |
| | 2 cyl. | 3 cyl. | 4 cyl. | 2 cyl. | 3 cyl. | 4 cyl. | 2 cyl. | 3 cyl. | 4 cyl. | 2 cyl. | 3 cyl. | 4 cyl. |
| Czecho-Slovakian State . . | 1 442 | ... | ... | 586 | ... | ... | ... | 13 | 69 | ... | ... | 34 |
| | 2 028 | | | | | | 116 | | | | | |
| Swiss Federal Railways. . | 170 | ... | ... | 139 | 2 | 1 | 141 | 147 | 152 | 1 | ... | 151 |
| | 312 | | | | | | 597 | | | | | |
| Belgian National Railway Company. | 2 150 | ... | ... | 1560 | 24 | 155 | 458 | ... | 101 | ... | ... | 31 |
| | 3 889 | | | | | | 590 | | | | | |
| Netherlands Railways . . | 987 | ... | ... | 224 | ... | 123 | ... | ... | ... | ... | ... | ... |
| | 1 334 | | | | | | 0 | | | | | |
| Swedish State . . . . . | 190 | ... | ... | 471 | ... | ... | 142 | ... | ... | ... | ... | 11 |
| | 661 | | | | | | 153 | | | | | |
| Norwegian State . . . . | 37 | ... | ... | 139 | ... | 27 | ... | ... | ... | ... | ... | 33 |
| | 203 | | | | | | 33 | | | | | |
| Bulgarian State . . . . | 52 | ... | 1 | ... | ... | ... | 132 | ... | 79 | ... | ... | 70 |
| | 53 | | | | | | 281 | | | | | |
| Rumanian State . . . . | 1 605 | ... | ... | 992 | ... | 38 | 807 | ... | 106 | ... | ... | 22 |
| | 2635 | | | | | | 935 | | | | | |
| Polish State. . . . . . | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | 3667 | | | | | | | | | | | |
| Danish State . . . . . . | 146 | ... | ... | 304 | 5 | ... | ... | ... | ... | ... | ... | 33 |
| | 455 | | | | | | 33 | | | | ... | |
| Total . . . (excluding Poland) | 11 570 | | | | | | 2 738 | | | | | |

# ompound engines (excluding shunting engines).

## 1st January 1928.

| Simple engines. | | | | | | Compound engines. | | | | | | Percentage of compounds. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Without superheater. | | | With superheater. | | | Without superheater. | | | With superheater. | | | |
| 2 cyl. | 3 cyl. | 4 cyl. | 2 cyl. | 3 cyl. | 4 cyl. | 2 cyl. | 3 cyl. | 4 cyl. | 2 cyl. | 3 cyl. | 4 cyl. | % |
| 1 507 | ... | ... | 1 122 | 7 | ... | ... | 11 | 105 | ... | ... | 41 | 5.6 |
| 2 636 | | | | | | 157 | | | | | | |
| 54 | ... | ... | 135 | 2 | ... | 8 | 54 | 10 | 1 | . . | 171 | 56.0 |
| 191 | | | | | | 244 | | | | | | |
| 1 370 | ... | ... | 1 692 | 15 | 203 | 237 | ... | 68 | ... | ... | 86 | 10.7 |
| 3 280 | | | | | | 391 | | | | | | |
| 737 | ... | ... | 330 | ... | 123 | ... | ... | ... | ... | .. | ... | 0 |
| 1 190 | | | | | | 0 | | | | | | |
| 65 | ... | ... | 524 | ... | ... | 106 | ... | ... | ... | ... | 11 | 16.6 |
| 589 | | | | | | 117 | | | | | | |
| 21 | ... | ... | 152 | ... | 27 | ... | ... | ... | ... | ... | 63 | 24.0 |
| 200 | | | | | | 63 | | | | | | |
| 54 | ... | 1 | ... | ... | ... | 169 | ... | 108 | ... | ... | 70 | 86.5 |
| 55 | | | | | | 347 | | | | | | |
| 1 208 | ... | ... | 1 679 | ... | 148 | 645 | ... | 73 | ... | ... | 20 | 19.6 |
| 3 035 | | | | | | 738 | | | | | | |
| 1180 | — | ... | 1243 | 2 | — | 1681 | ... | ... | 366 | ... | 93 | 46.8 |
| 2425 | | | | | | 2140 | | | | | | |
| 57 | ... | ... | 368 | 34 | ... | ... | ... | ... | ... | ... | 33 | 6.8 |
| 459 | | | | | | 33 | | | | | | |
| 11 635 | | | | | | 2 090 | | | | | | 15.2 |

# REPORT No. 2

(**All countries except America, the British Empire, China and Japan**)

## ON THE QUESTION OF THE USE IN RAILWAY WORK OF MACHINES FOR SIMPLIFYING STATISTICAL AND ACCOUNTANCY WORK (SUBJECT XIV FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1),

By Mr. BRUNEAU,
ASSISTANT CHIEF ENGINEER ATTACHED TO THE OPERATING SUPERINTENDENT
OF THE FRENCH MIDI RAILWAY COMPANY,

and

Mr. BOISTEL D'WELLES,
CHIEF ENGINEER OF THE OPERATING HEADQUARTERS OF THE PARIS-ORLEANS RAILWAY COMPANY.

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| | |
|---|---|
| Number of Administrations questioned . . . . . . . . . . . . . . | 147 |
| Number of replies received . . . . . . . . . . . . . . . . . . . . . . | 90 |
| Number of Administrations using calculating machines. . . . . . . | 33 |
| Number of Administrations using statistical machines . . . . . . . | 11 |

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## DIVISION OF THE REPORT.

The first part of this report is a general review of the principal appliances which may be used for carrying out accountancy or statistical work by mechanical methods. There can of course be no question of entering into technical explanations and frequently it has been necessary to assume that the reader is acquainted with the meaning of the terms or classifications employed. At the same time it was thought that a useful purpose would be served by giving a few details regarding the working of some recent appliances, particularly statistical machines.

Chapter II is devoted to a detailed account of the most important applications of which information has been received. In order to make this account instructive, it was thought a good plan would be to collate the various solutions given to comparable problems, and for that purpose to group the organisations described in a restricted number of categories.

The scope of this classification would have become excessively limited, however, if the authors had attempted to tie themselves down to the usual division of the principal departments which any Railway Administration demands. Although there are accountancy or statistical problems which are special to one particular department, there are many others of either identical or at least very similar nature pertaining to different departments.

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(1) Translated from the French.

In short it appeared that mechanical appliances could be usefully employed on work that could be grouped conveniently as follows :

1. Station work.
2. Traffic accounts and statistics.
3. Journey statistics. Calculation of running department premiums.
4. Statements regarding location of rolling stock.
5. Accounts of staff or labour expenses.
6. Stock accounts.
7. Cost accounts.
8. Various problems affecting general accounting work.

A special paragraph concerning organisation measures (concentration, more or less, of workshops, offices, etc., etc.), completes this chapter II.

Finally chapter III, the last, presents in the form of very general statements or recommendations the essential points arising out of this report which appeared suitable for submission to the approval of the Congress.

## CHAPTER I.

## General information regarding the principal appliances used for accountancy or statistical purposes.

### SECTION A.

### General. — Miscellaneous appliances.

**Essential classes of appliances.** — The appliances playing a really important essential part in the « mechanization » of accountancy belong to the following three categories :

Filing systems, fixed or movable.
Calculating machines.
Statistical machines.

**Miscellaneous appliances.** — It is true that accounting departments make use of a number of other machines of secondary importance, machines for binding, numbering, recording, etc. These being considered as pertaining to rationalization pure and simple and not to mechanization properly so-called, it is not intended to discuss them, and this refers also to certain devices fixed to typewriters in view of the fact that they can be specially adapted to the work under consideration (continuous duplication, billing machines, enabling accounts and detached sheets to be typed simultaneously, etc.). Similarly, appliances used for the mechanical transport of documents will merely be mentioned (1).

The *address printing or listing* machine is, among the appliances of secondary importance currently used, the only one about which we deem it necessary to enter into some details (even before referring to the calculating machine and the statistical machine — the three appliances are often used in combination).

Finally the ticket printing machine, the use of which is limited to station work, should be mentioned. We thought it preferable, however, to include details about this appliance in the part of chapter II relating to station work.

**Addressing or listing machines.** — In making certain periodical entries, each entry has to be accompanied by the same written information, for instance, the entries of the payments to employees give each month the surname, christian name, number, and rank of each person. By using listing machines the necessity of repeating this each time on the typewriter is avoided. Listing machines print with metal plates on which the necessary matter has been embossed by means of a stamping machine. These embossed plates are placed in the desired order in a magazine on the listing machine itself. On depressing the printing pad the preceding plate is ejected automatically, the paper is moved up, and a fresh plate from the magazine is brought into the desired position. These machines may be worked either by hand or electricity. The hand-operated machines can print 1 000 entries per hour, and the electrically-operated machines up to 2 500. The matter embossed on the metal plates may be removed, and the plates used five or six times.

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(1) We have received information of only one installation of this nature, by pneumatic tubes, erected in the Paris-Ivry station (Paris-Orleans Railway Company) and used for the transport of the consignment notes from the platforms to the accounting office.

## SECTION B.

### Filing systems, fixed or movable.

Notwithstanding the importance of these devices for mechanical methods of book-keeping, only a very brief reference will be made to them since they are already well known.

When the sheets or cards are not very numerous the flat-filing cabinets enabling the sheets or cards to be arranged horizontally and the necessary information to be written on them without their removal are of considerable utility (Burmo, Memos, and other systems). If, however, the cards are very numerous, or if the entries to be made on them are very complicated, vertical filing systems must be employed, and it may be very profitable to make use of movable card indexes of the « Roule-Class » type. These devices are simply sets of card indexes supported on a platform driven by a motor along steel tube runners, so that any card whatever can be brought within reach of the operator, who remains seated. A separate table fixed at one side of the « Roule-Class » and a swivel chair with a flexible back complete this installation.

## SECTION C.

### Calculating machines.

General. — Under this heading are included all machines carrying out simple arithmetical operations, whether provided with listing devices or otherwise.

The listing of the items of a calculation, at the time it is carried out, alone enables one to verify afterwards, by checking against the original documents, whether the necessary figures have been reported exactly. This possibility is of considerable importance.

It has not been a difficult matter to provide adding or subtracting machines with listing devices, and it may be said that the adding-listing machine particulary deserves attention for the type of work we are considering. Subsequently the advantage was recognized of being able at one operation to post all the entries, whether written or in figures, of accounting documents, hence the adding machines listing both letters and figures.

It is a much more complicated problem to design a machine which will perform multiplication and at the same time list the factors.

Finally, the problem of listing-division has not been solved.

The following classification results

from these preliminary explanatory remarks :

1. Non-listing calculating machines.

2. Adding machines listing figures only.

3. Adding machines listing letters and figures.

4. Listing, adding and multiplying machines.

1. **Non-listing calculating machines.** — Non-listing calculating machines may be subdivided into :

a) **Key-driven machines** (Burroughs calculator, Comptometer), very rapid but multiplying numbers of 5 or 6 figures only.

b) **Crank-operated machines** : These are further subdivised into « machines for multiplication by repeated additions » (in which, by setting the travelling carriage in motion, the multiplicand is transferred once to the totaliser), and « direct multiplication machines (1), in which a single movement of the carriage for each digit of the multiplier transfers the multiplicand to the totaliser a number of times equal to the particular digit of the multiplier. The machines most frequently used in organisations of any importance belong to the category of those which multiply by repeated additions (Mercédès, Madas, Monroe, Marchant, Archimede, Brunsviga, Sanders, etc., etc.).

All the important makes include hand-operated models and models driven by electricity, the latter being used in increasing numbers since they speed up the output by 30 to 40 %.

Electricity has also enabled automatic devices which were in vogue before its use to be improved and extended. Several makers of calculating machines (Madas, Marchant, Mercédès) comprise automatic types. They are usually entirely automatic as regards division. Multiplication either consists of as many successive automatic operations as there are figures in the multiplier (Marchant and Madas machines) or is effected in a continuous manner once the machine has been set for the multiplicand and multiplier (Mercédès machine and the new Madas model). These last mentioned machines alone may be characterised as being entirely automatic, enabling other work to be carried on while the machine is operating. Apart from being absolutely automatic the Mercédès machine offers the advantage of possessing two totalisers, one accomodating the partial products, and the other accomodating the multipliers successively applied to the same multiplicand (a very useful method of checking when, for instance, these multipliers are the percentages of a total equal to 100).

The advantage accruing from the use of automatic machines depends mainly upon the nature of the work to be done. The advantage would be almost nil, for instance, for calculations for verifying charges (successive multiplication of a tonnage by a price and by an increase factor), the operator being unable to carry on any work before knowing the final results. On the other hand, the automatic machine is advantageous when it is a question of obtaining separate products of the same multiplicand by several multipliers (apportionments), the operator being able to write down the successive results while the machine is working.

It is outside the question to indicate

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(1) It may be pointed out that the travelling carriage of direct multiplication machines in a way roughly represents the various numbers of the Pythagoras table.

here the details of design or construction differentiating the many types of machines in use for multiplying by repeated addition. The differences eventually make themselves felt in fairly wide variations in prices and speeds; the differences in speed themselves vary oftener than not according to the type of work to be done, so that the judicious choice of a machine implies a very close examination of the extent to which each of the various elementary operations enters into the use of the appliance.

There remains to be mentioned the only direct multiplication non-listing machine, namely, the Millionaire machine (¹). This machine, which is absolutely reliable in operation, has a greater speed than non-automatic machines multiplying by repeated addition. It possesses a totaliser for grand totals but although it costs very much more than the Mercédès, it does not, as a rule, enable such a great speed to be attained as does the last-named machine.

2. *Adding machines listing figures only.* — These machines belong to the category of crank-operated machines and the same turn of the crank or in the case of the electrically-operated machines, the depression of the same key, causes the number to be transferred to the totaliser and listed. The sum accumulating in the totaliser is listed in turn by depressing a « Total » key (and in this case the totaliser is cleared) or « Sub-Total » (and in this case the total remains registered in the totaliser to be added to the succeeding totals).

The registering device may consist either of a full keyboard, that is to say, one having a key for each digit (Burroughs and Barrett machines) or of a small keyboard (Astra, Dalton, Sundstrand, etc.), in which case the number is registered in the form of projecting stops on a kind of interior carriage called « intermediate keyboard ». Each time a key is depressed this carriage is moved along so that, after registering, each projecting stop is brought opposite the desired figure type. It is evident that this correspondence can only be attained by striking all the figures. There is no need, on the other hand, to strike the zeros in machines having a full keyboard. For this reason, and also because with them it is possible to depress several keys at the same time, these machines enable trained operators to attain a greater speed, other things being equal, than do machines having small keyboards. The last-mentioned, however, do not lose much in popularity on that account for they can be operated by practically untrained persons.

The keyboards of some makes of machine are fitted with abbreviation keys, thus to some extent making up for the absence of a letter keyboard.

In general the adding machines which only print figures differ from those which print letters not only by the absence of a letter keyboard, but also by the small number of their counters [two splittable (¹) counters] and the impossibility of totalling the same number at the same time in two totalisers working in different directions (one vertical and the other across). Every machine can, however, totalize successively either horizontally or across, the carriages attain-

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(¹) Further on, reference will be made to a direct multiplication listing machine, the Burroughs-Moon.

(¹) Splitting consists in dividing up a counter into a certain number of others, the total number of figures remaining the same.

ing 75 cm. (29 1/2 inches) in length for the purpose of cross adding.

The two counters may be utilised either to register series of different numbers or to register the same numbers, one of them providing the sub-totals and the other the grand totals.

Some machines (ordinary Burroughs) cannot subtract except by the method of complementary numbers, while others (Sundstrand, Burroughs-Multiplex) carry out subtraction direct.

Some machines may be occasionally used as non-listing multiplying machines, being provided with repeating keys and devices enabling the decimal order of the multiplicand to be changed. This change is effected either by automatically clearing the totals (machines having full keyboard), or by clearing the intermediate keyboards (machines having reduced keyboard).

Adding machines with two counters are noteworthy for their great speed of operation due to the fact that they can be made absolutely automatic. Once the work has been planned, the automatic nature of the operation does away with any necessity to depress the various « total, sub-total, no addition, subtraction, report », keys, which are employed in working a non-automatic machine.

Machines which cross-add are specially suitable for keeping accounts which contain entries involving both addition and subtraction (pay sheets, accounts, stock sheets, etc.). Owing to their being completely automatic they may even, for certain summarizing work, surpass in speed the accounting machines to be discussed later, in spite of the advantage possessed by these last-mentioned machines of being able to add in both directions at once.

The results of calculations by adding machines cannot be considered certain unless it has been possible to check both the readings and the satisfactory working of the counters. It is very important that the system of using these machines should, in itself, include special checks, ensuring facilitating this verification. If, for instance, the same basic documents successively arranged in different orders are to be the object of two series of partial additions, the agreement of the grand totals registered in the second counter will provide the double check referred to above. If the system of work involves a double addition in the two directions (across and vertical) the agreement of the total results will again ensure that the counters are working correctly, but it will still be necessary to guard against errors in reading by checking the tables set up by the machine against the basic documents, unless it is possible to carry out the second addition on inspecting the basic documents themselves.

The supplementary totals or various checks which have to be made in the absence of special checks in the programme of work may result in limiting considerably the use of these machines.

When, as frequently happens, adding machines are used for making entries on loose leaves or cards, it is necessary, in order to be able to check the operations, that some entries should be made and totalised at the same time on a continuous sheet. For this purpose the carriages should be provided with special devices so that the continuous list and the loose card may be printed either simultaneously (when the additions on the card are vertical), or the carriage may be split, only a portion of it being used to print the list (when cross-additions are made on the cards.

There are two types of adding machines

which do not answer to the general descriptions that have just been given.

In the first place, these are machines of the Burroughs-Mutliplex type, possessing a cross-splittable totaliser in which any number may be registered (either in addition or in subtraction), at the same time as in any one of the vertical totalisers. The number of vertical totalisers may attain 6, and by splitting them 12 counters can be used readily. The keyboard is equipped with a number of abbreviation keys. Taken all in all, and disregarding the writing keyboard, the possibilities offered by the Burroughs-Multiplex are very similar to the accounting machines discussed further on in the report. Being stronger, and certainly more durable, and having a less delicate mechanism than accounting machines having movable counters, this machine in addition enables a greater speed to be attained in some classes of work. It is the standard machine for making out invoices, for keeping accounts or cost sheets up-to-date, etc. Accounting machines recover their lead when a large number of entries have to be dealt with. Finally, and this refers especially to railway administration, the Burroughs-Multiplex machine frequently possesses the disadvantage of being too restricted in capacity.

The well-known types of « cash-registers » should be included in the second rank of the general category of adding-listing machines. As is well known these appliances may be provided with twenty or more counters but except for station work, with regard to which something will be said later, they are scarcely ever used in accountancy work, the totals registered in the various counters being printed on one continuous roll of paper.

3. *Adding machines listing letters and figures.* — These machines are often called « accounting machines », it being understood that they are capable of posting all the items of an account. Although this name is open to criticism (simple adding machine being also largely used for accounting work), it will be used for the sake of brevity.

Accounting machines are divided into machines with fixed counters (Underwood, Ellis) and machines with movable counters.

Machines with fixed counters have only 5 or 6 counters. The remarks made previously in connexion with the Burroughs-Multiplex machine are applicable to these machines also.

Machines with movable counters (Remington, Mercédès, Smith Premier, Elliott-Fisher, etc.), enable one to place on the carriage up to 20 or 21 vertical totalisers, the width and spacing of which may be varied as desired.

These machines are always provided with at least one special totaliser, and more frequently with two special totalisers on slides, called « cross adders » placed on one side of the frame, under the carriage, and intended for cross adding. By means of a suitable arrangement any number registered in a carriage totaliser may be simultaneously added or subtracted in one of the cross adders.

The machines under consideration are almost all small keyboard machines. Their method of working, as described above, offers certain differences, which would appear useful to note because they explain why one or other class of machine is to be preferred according to the nature of the work. In accounting machines the numbers are printed and transferred to the totaliser automatically by depressing the keys, without having to operate any special keys. On the other hand (and this constitutes the counterpart of the special feature just mentioned), it is necessary before registering a number to bring the carriage in front of the necessary digit of the totaliser by depressing the tabulating keys. The totals registered in the totalisers are not printed directly (as is done in adding machines by depressing a total or sub-total key). In order to print vertical or cross-totals it is necessary to depress the keys corresponding to the number read on the totalisers. If desired, the totaliser may be cleared by this operation (in which case a checking device locks the machine if, by an error in reading, this result is not produced). Lastly, a cross-adder cannot be cleared unless the sum is transferred to one of the vertical totalisers specially reserved for this purpose.

To sum up, the provision of movable counters is not without its effect in introducing some complications in the working of the machine, and in restricting the possibility of making the operations automatic. Further, machines with movable counters require more attention and their mechanism is more delicate (great care should be taken, especially in moving the counters, and in this lies the advantage of keeping the work done by the machines as constant as possible).

In all these machines the progressive displacement of the carriage is done by electricity In some makes the carriage is also brought back to its starting position by electricity (an arrangement which is chiefly of interest in considering female operators, and which moreover, in certain cases, may have the disadvantage of reducing the speed). Finally the depression of the keys may be done by electricity (Mercédès machines).

The price of a machine with movable counters and 20 totalisers is round about 60 000 francs.

4. *Adding and multiplying listing machines.* — The printing of the multiplicand at the moment this number is registered on the keyboard of a multiplying machine, or the printing of the product by the depression of a special key, once this product has been registered in the totaliser, do not offer any problems other than those which have been solved in ordinary adding machines. The same does not apply to the multiplier which is registered by runners or on a special keyboard.

In fact the Burroughs-Moon, the only listing multiplying machine which existed up to quite recently, requires two distinct operations of the keys for the multiplier, one for the calculation and the other for printing, there being no connexion between these two operations to guarantee that identical numbers are struck each time. It may be said, therefore, that the Burroughs-Moon machine in itself, despite its very improved character, does not entirely solve the problem of printing as far as multiplication is concerned.

This machine, which lists letters and figures, is at one and the same time a calculating machine (by direct multiplication) and and accounting machine (it is provided for this purpose with 5 to 6 adding-counters, one of which may be used for cross-adding). In addition to a typewriter keyboard, it is provided with two calculating keyboards. On the first are registered the sum to be added or the multiplicand (the multiplicand may also be transferred directly from one of the adding-totalisers to the multiplier). On the second key-board is struck the multiplying factor, and this operation is sufficient to carry out the multiplication.

The fact that the calculation and the printing of the multiplicand and product are made simultaneous enables an increase in speed, estimated by some administrations at 50 %, to be obtained, as compared with the use of a multiplying machine followed by an adding-listing machine, or of an accounting machine. This machine costs about 50 000 fr. and despite the fact that, owing to its very principle, it is delicate in operation, it is an extremely valuable appliance, although it is often unfortunately somewhat restricted in use owing to the small number of adding-counters. The *Madas* firm has just effected the electrical combination of their fully automatic multiplying machine, referred to earlier, with an accounting machine, a combination which solves the problem of the adding and multiplying listing machine. As in the Burroughs-Moon machine, the multiplicand and the product are printed directly while the multiplier has to be struck twice, once for the calculation and once for printing. Interlocking would ensure the identity of the numbers struck by these two operations. This combined machine having only just been put on the market, it is not possible to give a definite opinion concerning it, particularly as regards the efficacy of the device for checking the registration of the multiplier (the Burroughs-Moon machine was originally fitted with a device of this nature, which had to be discarded later).

## SECTION D.

### Statistical machines.

Under this heading is included the whole of the equipment enabling :

1. Certain entries on the basic documents to be reproduced by perforations on cards;

2. Cards to be sorted into the order required for additions or for printing direct according to desire;

3. Certain entries on each group or sub-group of cards arranged in this way to be totalized or sometimes merely printed.

We are acquainted with only three makes of statistical machines, the Hollerith, Powers, and Samas machines, combining in a single unit the three machines by which the above operations are carried out. The two last-mentioned machines are very similar to one another and will be treated together in the descriptions given below.

#### 1. Punching machines.

The punching machines of the various makes all have 12 perforating keys, ten of which are numbered 0 to 9, and two enabling perforations to be made outside the columns. Two other keys are used for regulating the movements of the cards.

In addition to this the different makes of punching machines differ in the following points :

*Powers punching machines.* — These machines are driven electrically. Depressing the keys merely places and locks the punches in the desired positions. By the action of a tabulator the card is passed from a magazine to the punching device, where it is punched at a single stroke and ejected automatically.

Any punch may be locked permanently, thus avoiding the necessity of re-perforating common entries.

*Hollerith punching machines.* — Four types of punching machines are made :

*a*) Hand-operated punching machines. Punching is direct, the card being moved forward by one column for each perforation;

*b*) Electrical punching machines. The principle remains the same, but the punches are actuated electrically, the effect of depressing the keys being merely to close the circuits;

*c*) and *d*) Electrical multi-punching machine and series punching machine.

These two appliances are used to reproduce on a card automatically, and at a single operation, information previously punched on a master card.

The series punching machine does not differ from the multi-punching machine except that instead of having to place the cards in position one by one by hand, the cards which are to receive successively these perforations are previously introduced into a magazine from which they are taken automatically and continuously to the punching plate. The series punching machine can perforate 7 000 cards per hour.

The Hollerith hand-operated punching machine and even the electrically-operated punching machine of the same mark are much slower than the Powers punching machine when (and this occurs most frequently) a certain number of punching machines can be set for fixed work. By the combined use of hand-operated Hollerith punching machines and multi-punching machines this difference in speed per unit can be reduced to a fairly low figure and the over-all punching costs may even be equalized, the price of the Hollerith appliances being considerably lower than the others.

Electrically-operated Hollerith punching machines, combined with multi-punching machines or series punching machines, enable the same output to be attained per unit as the Powers machines, the costs remaining practically the same (the Hollerith electrical punching machines offer particular interest when it is a question of punching two identical cards for each basic document).

### 2. Sorting machines.

The Powers and Hollerith sorting machines are horizontal (¹). The cards are placed in a magazine from which they pass automatically into the sorting mechanism. This mechanism causes them to fall into one of the thirteen receptacles of the machine; twelve receptacles correspond to the twelve possible perforations of the card, and the thirteenth receives the rejected cards bearing no perforation in the selected column.

In the Powers sorting machine, the selecting device is purely mechanical and consists of twelve pins (the pin coming opposite a perforation goes through it and causes the corresponding receptacle to open. Any number of selector pins may be put out of action, by which it is possible to select only those cards corresponding to certain positions, without disarranging the original order of the remainder.

In the Hollerith sorting machine, the selection is carried out electrically by means of a revolving cylindrical distributor, bearing on its periphery twelve brushes which make the desired electrical contacts. Any number of brushes may also be put out of action.

The two makes of sorting machines, Powers and Hollerith are quite similar as regards quality and speed (400 cards per minute).

### 3. Tabulating machines.

Tabulating machines are adding machines in which the figures are transfer-

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(¹) The Hollerith vertical sorting machine is no longer made.

red to the counters by the passage of perforated cards.

Originally special cards called space cards, inserted wherever desired either caused the machine to stop (in the case of non-listing tabulating machine) so as to enable the counter to be read, or (in the case of listing tabulating machines) caused the total to be printed and the counters to be cleared.

Recent models with automatic control are being used more and more. In these machines a change in perforation in any one of the indicating columns causes the counters to be released (the machine stops after the last card in each group has passed through, prints the total for this group, and starts again). There are models which print as desired; either just the totals registered in the counters, or all the numbers totalized and their totals. Finally a certain number of simple counters are provided in addition together with a grand totaliser registering the same numbers and accumulating the sub-totals. In this way it is possible to obtain the totals of each group of cards and the grand total of the whole distinct batch which has been passed through the machine.

Profiting by these remarks, which may be considered as applying to both Hollerith and Powers machines, the following are some of the essential points in which the two makes differ :

1. The Powers tabulating machine is equipped with 7 counters of 10 figures, all of which may function alike either as simple indicators or totalisers properly so-called. The machine is equipped in addition with 3 or 4 grand totalisers, to the use of which reference has already been made.

The Hollerith tabulating machine possesses 5 counters of 9 figures, which may function alike either as simple indicators, or as totalisers properly so-called, and 2 sections of 10 figures, which act solely as indicators. Grand totals, when required are obtained by means of one or more of the 5 totalisers.

2. The Powers automatic control can affect any one of the columns and all positions outside the columns.

The Hollerith automatic control can only affect 10 columns, and has no effect on positions outside the columns.

In brief, it is not to be contested that the Powers machine affords possibilities of tabulating on a much wider scale than the Hollerith machine.

3. In the Hollerith tabulating machine this lesser capacity for totalizing is compensated for by its extreme flexibility in operation, due to the fact that the totalisers are actuated by means of electrical connexions, which can be altered with the greatest ease, while the connexions in the Powers machine consist of rigid needles assembled in a box, each definite piece of work requiring the use of a special box of needles at a rather high price.

4. The speeds attainable by the Hollerith and Powers machine working *as full* printing or « listing » machines are quite comparable : about 70 or 65 cards per minute, counting a total for every 3 cards. As non-printing or « tabulating » machines, the speed of the Powers machine remains the same, whereas that of the Hollerith machine is raised to 150 cards per minute.

5. The Hollerith tabulating machine can be fitted with a special type of automatic control called « major and minor » enabling two grouped counters (sub-total and grand-total) to be actuated by different « indicating » columns. For instance

it is possible in this way to obtain in one counter the tonnage transported of a certain class of goods, and in a second counter the tonnage of all the goods pertaining to a more general group of charges (a result which in the absence of major and minor control could not be obtained except by separating, before tabulating, the cards relating to each of these general groups).

### 4. General considerations. Verification.

The preceding remarks only deal with arrangements usually existing in statistical machines, but the manufacturers of these machines rival one another in seeking to effect improvements in detail capable of expediting the work. A few instances may be quoted. Frequently the number of columns on a card is insufficient for perforating all the useful data. When some of the data to be totalized are mutually exclusive, it is possible to allot to them the same group of columns, the instance where the perforation refers to one of the data in question being distinguished by a special perforation outside the columns. In tabulating, the data in question, although appearing in the same columns, are transferred by means of a special connexion to two separate counters. This device can be fitted to both the Powers machine and the Hollerith machine.

The Netherlands Railways mention an arrangement of the Powers sorting machines designed to remove to the « reject » receptacle all cards not accompanied by a second card bearing certain perforations which are identical with those of the first.

The Hollerith and Powers electric drive punching machines may be connected to the keys of a calculating machine or an adding-listing machine, a combination which may enable the time required to punch the cards to be saved, or which may procure some garantee of the accuracy (1) with which the punching is performed.

A small proportion of errors in punching appears to be in fact unavoidable, even on the part of trained operators, and the use of these statistical machines should always be organised in such a way as to enable these errors to be discovered.

The most favourable case is that where the programme of work provides a special checks which does away with all other verification.

More generally it will be necessary to have recourse to direct methods of checking. Often the results are verified approximately, at sight, based on certain special checks which should exist between the indications on the cards. One of the first methods of completely verifying the cards was to put them through a verifier, a machine similar to the punch, the action of which is merely to leave an impression at the points of the card which have not been perforated as they should have been.

This procedure is tedious (for the speed of the verifier is hardly more than twice that of the punching machine), and generally it can only be used as a trial.

A procedure which is more frequently employed consists in tabulating, before any sorting operation, certain data on the cards and comparing the totals so obtained with the results of a direct addition made on an adding machine from the basic documents.

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(1) When a multiplying machine is associated in this way with a punching machine the accuracy can only be guaranteed as regards the multiplicand and multiplier, but not as regards the product.

It may be assumed that the verification of the cards forms an important cost item which it is essential should not be neglected in examining a programme of work.

It is also expedient to take into consideration the errors which may be ascribed to the machines themselves (sorters and tabulators). In this respect the essential point is to see that the firm supplying the machines attends very carefully to their upkeep. If this is done the errors of operation become very rare incidents.

The attention of the operating staff should also be kept on the alert, and by passing checked cards from time to time through the machine it will be possible to discover readily any systematic disorders. It is true that there still remains the possibility of exceptional and temporary failures in the working either of the connexions or of the counters. Theoretically, in the absence of any special intrinsic check in the programme of work (such checks retain all their importance when using statistical machines) it would be necessary, in order to protect oneself against such failures, to tabulate twice in succession by modifving the allotment of the counters. Such a method of checking is, however, much too tedious, and could not be considered except on very rare occasions.

*Prices.* — The preceding remarks are sufficient to enable one to foresee the advantage which may be obtained from statistical machines, except when there is need to provide oneself with every necessary guarantee of the absolute accuracy of the results. It should not be forgotten, however, that any organisation of this nature involves fairly considerable expenses both as regards the cost of cards and the hire of the machines (1) (price of cards, 33 fr. per 1 000). Monthly hire of a sorting machine 1 200 fr., and of a Hollerith 5-counter tabulating machine fitted with all the latest improvements, 6 to 7 000 fr.

Taking these figures into consideration and working on a basis of 200 hours' work per month, the cost per hour per sorting machine and per tabulating machine, including the wages of the operators, would be, respectively, of the order of 15 fr. and 37 fr. (2).

These remarks are sufficient to show that the use of statistical machines can only be profitable if the programme of work satisfies certain conditions. It is evident *a priori* that this advantage mainly depends upon the number of times each card is passed through the sorting and the tabulating machine, the number of data simultaneously totalized at each tabulation, as well as the average number of figures in each of the data to be totalized. There is, however, another factor which affects, in a marked degree, the respective advantages of employing statistical machines and ordinary methods. This is the average number of separate items forming each total, or more generally, the number of separate batches which, in the absence of a machine, would have to be arranged by hand and then totalized. If, in fact, one may roughly compare, as operating principles, handsorting with the sorting machine, and considering the duration of either to be proportional to the product $N \times p$ of the number of separate documents by the number of passages of each document, the separation and the arrangement of documents into batches by hand form a considerable additional piece of work when each batch only contains a small number of separate documents. This multiplicity of batches may become so great as to necessitate copying the documents on registers or sheets. The advantage of statistical machines depends in a great measure upon this factor.

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(1) As regards sorting and tabulating machines, the Hollerith Company only allow their machines to be hired out to users. The Powers Company, on the other hand, both sell and let out on hire. Hiring is the more advantageous method for railway systems, because, even when the machines are bought, it is still necessary to call in the aid of the supplying firm for the upkeep of the machines.

(2) When an office is equipped with several tabulating machines it is usually possible and profitable to have two machines operated by one employee, the very small loss in speed resulting therefrom being far from affecting the saving due to reduction in staff. In this case the cost per hour per tabulating machine is reduced to 33 fr.

It must not be thought possible to interpret, by a general expression of the various data which have just been enumerated, the balance comparing the use of statistical machines with ordinary methods (handsorting and adding machines). It appears however, that some interest attaches to a closer examination of the various items of this balance in an attempt to form some very rough and approximate idea of their respective orders of magnitude.

For the purpose of fixing our ideas, let us consider a card which is to receive thirty perforations; the cost of the perforated card will be about 0.08 or 0.09 fr., as follows :

| | |
|---|---|
| Cost of card . . . . . . | 0.033 fr. |
| Punching. . . . . . (speed of 180 cards per hour). | 0.050 fr. |
| Upkeep and depreciation of punching machine . . | 0.002 fr. |
| | 0.085 fr. |

Taking the hourly wage of a handsorter to be practically equal to half the cost per hour of the sorting machine, say 7.50 fr., and the speed of sorting to be 50 manipulations per minute by hand and 350 per minute by the machine, the saving effected per *passage* and per *card* would work out to

$$\frac{7 \text{ fr. } 50}{50 \times 60} - \frac{15 \text{ fr.}}{350 \times 60}$$

or practically 0.002 fr., a very low figure compared with the cost of punching the cards (1).

For 10 passages only 0.02 fr. would be recoverd on the 0.085 fr. expended on punching.

The portion of the work of statistical machines which is really remunerative is the work of tabulating.

An hour's operation of the Hollerith machine totalizing, and « tabulating » $n$ data of an average of 5 figures each at the speed of 110 cards (2) per minute, practically saves the work of 8 $n$ hours with adding machines (3). A simple calculation similar to that given above, shows that the saving on each separate document and on each tabulation would be about

$$0.010 \text{ fr. } n - 0.005 \text{ fr.}$$

If the number of totalized data is 3, it will be seen that each tabulation would save practically 0.025 fr.; four tabulations would therefore more than cover the expense of punching the card.

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(1) This rough calculation does not take into consideration those cases where the excessive multiplicity of the batches of documents gives rise, in hand-sorting, to the complications referred to above.

(2) This speed assumes an average of 10 entries for each total.

(3) Assumed speed of an adding machine : $\frac{110}{8} = 13$ numbers per minute.

A similar calculation enables one in a rough manner to appreciate the use which is sometimes made of statistical machines to replace entirely the calculating machine and the adding machine. When it is necessary to multiply together a series of numbers and factors, and only the total of these partial products is required, a card can be punched at each operation with the factor and the multiplicand, and these cards can then be sorted and tabulated according to each column of factors.

If, in order to take a concrete example, the factors have three figures at the most, thirty multiplications and as many additions will be sufficient to give the required total. This method, which is seldom profitable when the factors affect only one series of numbers, may on the contrary become so if the same factors each affect several multiplicands which can be carried on one and the same card.

Let us assume again that the factors are three-figure factors and that there are $n$ series of multiplicands, such that by means of the Mercédès automatic calculating machine the operations can be carried out at the rate of 330 per hour. If the use of the Mercédès machine costs 11 fr. per hour, each operation costs practically 0.035 fr., to which figure should be added the cost of totalizing the partial products, say about 0.01. fr. making a total of 0.045 fr. per partial product.

The use of statistical machines would involve approximately the following expense, per partial product :

$$\text{Punching : } \frac{0.085 \text{ fr.}}{n}$$

$$\text{Sorting : } \frac{0.003 \text{ fr.}}{n}.$$

$$\text{Tabulating : } \frac{3}{n} \times \frac{37 \text{ fr.}}{150 \times 60} \text{ or } \frac{0.012 \text{ fr.}}{n}.$$

and the total would be $\dfrac{0.10 \text{ fr.}}{n}$

It will be seen that the use of statistical machines is not profitable unless $n > 3$.

(It should be repeated that only a very roughly approximate value should be placed on these figures, which are intended merely to indicate the orders of magnitude.)

Apart from the general conditions arising out of the considerations given above, it is further necessary, if the use of statistical machines is to be profitable from a pecuniary standpoint, that the work to be done should be fairly large unless the execution of the work can be alloted to another organisation as a supplementary piece of work.

On the other hand, it will be seen that the use of statistical machines may be justified, apart from any question of economy, in making statistics on various investigations which could not be done otherwise.

Finally, the rapidity of operation of sorting and tabulating machines may also justify the use of these machines for work which has to be done on very short notice.

## CHAPTER II.

### Chief applications.

*Preliminary remarks.*

In the following account an endeavour has been made to give, according to the information provided by the administrations, the main objet of each of the organisations described. In those cases, by far the most general, in which the mechanization satisfies some economical object, the administrations have more often than not restricted themselves to giving the saving in the number of employees, without stating precisely the magnitude of the cost of procuring the appliances to be placed on the debit side.

Since after all it is a question of a fairly small number of machines, it will be a relatively simple matter, by assuming the costs to be of the same order of magnitude as those mentioned in the first part of this report, and assuming as a basis a duration of 5 or 6 years for the depreciation of the machines, to form a sufficiently approximate idea of the interest afforded by each operation. Thus, to give a concrete example, in the case of an adding machine listing letters and figures, with about twenty counters and costing about 60 000fr., the depreciation of this machine (in five years) and its upkeep correspond to an annual expenditure of the order of 15 000 fr. The operation of the machine can only be profitable if it has been possible to dispense with more than one employee. In practice it will only be so if two employees have been dispensed with.

The information provided by the various administrations consulted calls for another remark. It would appear that, in most instances, the total saving of staff has been calculated in relation to the previous organisation, without making any distinction of that portion of this saving which may have arisen from measures of rationalization pure and simple, consequent upon the use of the machines, but which might have been realised otherwise.

Profiting by these general remarks we shall proceed to examine the chief general applications which have been reported.

## SECTION A.

### Station work.

1. *Printing and issuing tickets.* — The desire of speeding up the issue of tickets, and of affording a protection against fraud implies the use as widely as possible of passenger tickets bearing the fare and the destination printed in advance.

The use of these tickets, called « fixed destination tickets » does not entirely remove the temptation on the part of employees to commit frauds, and gives rise, moreover, to considerable inconveniences. A ticket case has to be allotted to each employee who may have to help in the issuing of tickets during the day, whence, as a first consequence the necessity of extending the booking offices and of increasing the number of ticket-windows. The limits which are perforce set, in this respect often form, moreover, an obstacle to the most economical regulation of the hours of duty of the booking clerks, chiefly making it impossible to have short reliefs during slack periods.

Finally, each clerk, in order to post his books, must take stock of his tickets at fairly frequent intervals, and write involved statements, all of which may represent several working days per month.

Attempts have been made to remedy the first of these drawbacks either by authorising each booking-clerk to have an assistant under his own responsibility, the additionnel assistance and responsibility being paid by contract, or by having movable ticket cases, and arranging underneath the ticket office, connected with it by a hoist, a room in which the ticket-cases are kept and the book-keeping is done (French Midi Railway, Bordeaux-Saint-Jean station).

The use of ticket printing machines provides a complete solution.

These machines (A. E. G. make) consist essentially of :

— a partitioned case, inaccessible to the operator, and containing a certain number of stereotyped metal plates, placed vertically in juxtaposition and bearing all the information characterising the ticket.

— a printing carriage which may be moved longitudinally and laterally at the same time so as to be brought over any plate, the precision of this operation being obtained by means of a rotating indicating multi-sided drum, driven positively from the carriage, and bearing on rolls of paper on its faces the information on all the metal plates.

When the printing carriage arrives in a position above the plate, and the ticket-card has been placed in the carriage the action of a number of levers causes the plate to be raised, placed in its turn in the carriage and the information on it plus a number and the date to be printed on the ticket-card, and at the same time causes the number of the plate, that of the ticket and the price, to be printed on two control paper rolls, one of which is accessible and the other inaccessible to the operator. On going on or coming off duty, each operator causes a control ticket to be printed by the same carriage. This ticket, being also numbered, enables the issuing of all the tickets to be individualized without any risk of error. Moreover the operator takes out and retains the accessible control roll by which he is enabled to check his cash.

These machines may be provided (in numbers limited by technical conditions of installation) with individual counters registering for statistical purposes the number of tickets sold corresponding to certain plates. By allotting these counters to the largest numbers of tickets it is possible also to analyse a considerable proportion of the traffic.

Only four administrations have mentioned the use of these machines (Czecho-Slovakian State Railways, the Netherlands Railways, the French Est Railway, and the French State Railways).

The Czecho-Slovakian State Railways use five machines in the various stations of Prague. The French Est Railway have decided in principle to equip in this way all the suburban service of their new station.

This service will consist of one machine of normal output of the 1 500-ticket type issuing tickets of the three classes, two machines of the 1 000-ticket type issuing 1st and 2nd class tickets only, and 15 machines of the 500-ticket type issuing 3rd class tickets only (by reducing the number of machines issuing 1st and 2nd class tickets the costs can be reduced considerably). The over-all cost will be about 1 200 000 fr. in regard to which amount should be mentioned :

1. A saving of 10 employees.

2. A supplementary income of about 100 000 fr. derived from the use of premises which will become available for business purposes. The French Est Railway Company are also considering the question of equipping their main-line services with machines of the 2 000-ticket type but have not yet come to a definite decision, the high cost of the 2 000-ticket machines reducing to a very small amount the immediate profits to be derived from their use.

The French State Railways propose on their side to equip with ticket machines all their suburban service, which is very heavy, of the St. Lazare station, as well as the mainline service of the Montparnasse station where space is very restricted.

The French State Railways are even considering the use of A. E. G. machines in the intermediate suburban stations, which are very confined, and to which the work of the booking office alone would necessitate extensions.

In addition to the ordinary type machines described above, the French State Railways are intending to use « *rapid distribution* » machines at the St. Lazare station. Each of these machines only delivers about twenty tickets, and they will be used for the issue of tickets on particulary heavy routes during busy periods.

It would be very useful if the same cash accuracy could be obtained in issuing contract tickets, large numbers of which inevitably continue to be used, even at the large stations, owing to the various reductions available on the ordinary fares. The simplest solution which presents itself would be to use tickets on which was printed nothing but the name of the station of departure and destination and to have printed on them the class, reduction in fare, and the price by means of a machine of the general type of « cash registers ».

The French Est Railway Company is considering a solution of this nature.

Perhaps the same solution would enable contract tickets to be issued by certain Traveller's Agencies, which up to the present, have in certain countries been authorized to issue only fixed tickets.

2. *Franking machines.* — Following up the same trend of ideas, the Norwegian State Railways are using « franking » machines in about fifteen of their large stations for franking way-bills of carriage paid goods. Machines of the same kind have also been installed by this administration in a number of large forwarding houses. The forwarder himself computes the carriage and prints the amount on the way-bill. The accounts are adjusted fortnightly. It would be interesting to know if, as regards consignments by weight which are subject to complicated charges, the rectification of the charges which the railway may have to make after examination of the goods, do not diminish considerably the practical interest afforded by these machines. (This inconveniences would not, however, have any effect on the forwarding of goods on fixed charges such as parcels going through the post).

3. *Station accounting requiring multiplication.* — Accounting work involving multiplication is restricted in railway stations to keeping the passenger accounts, and the freight charges and their verification on arrival of the goods.

In calculating the charges it appears that in Switzerland and Belgium fairly considerable use is made of multiplying machines (particularly Comptometers). In France the State Railways (40 machines) and the Est Railway Company (a few machines only) alone make use of machines. The French State Railways state that in one of their stations, it has been possible to organise a rates department previously employing 6 clerks, so as to employ 3 rates clerks and 1 machinist.

Even taking into consideration the fact that the machines allotted to the work in question are probably only used part of the day, it would appear a priori that they should be used on a more extensive scale, since the appliances in question are not very costly.

4. *Station accounting requiring additions.* — The accounting work of railway stations whether it is matter of keeping the traffic accounts or the general accounts demands much adding work. Even in the large stations, however, the posting of the traffic accounts is the only work which might justify in itself the use of machines (the remaining station accounts or cash accounts would only demand the occasional use of machines).

The Belgian, Swiss, and Norwegian Railways make a fairly large use of adding non-listing machines or adding machines listing figures only.

In France, on the State Railways (26 machines), the Est Railway (17) and the Nord (54) the large stations use accounting machines for posting all the arrival accounts, a document having 10 to 12 columns of entries.

The concordant information provided by the French State Railways and the French Est Railway enables the hourly speeds obtained to be computed approximately as follows :

| | | | | |
|---|---|---|---|---|
| Working by hand . . . . . . . . . . . . . . . . . . | 200 | slow | train | arrivals. |
| With non-electric machine . . . . . . . . . . . . . . | 400 | » | » | » |
| With electric Remington machine . . . . . . . . . . . | 570 | » | » | » |

The last figure emphasises the advantage in using machines.

### General remarks.

On the whole the mechanization of the accountancy work in the large stations is still somewhat restricted, which seems to arise from number of causes. There is, first of all, the irregular nature of the accounting work carried out in station offices during the course of the day, an irregularity resulting unavoidably in an excess of staff at the slack periods. The lack of permanency in the female employees of stations, and the frequent necessity of training new girl operators also assist, it is believed, in discouraging some Railway administrations from making use of machines. From a more general point of view, owing to the very fact that the departments to be organised are small, the use of machines in station accountancy work gives rise to special difficulties. Finally, the small or medium-sized stations are beyond the range of all possibility of using them.

These various considerations may lead one to vizualize the creation of a kind of central station where the accountancy work, which is not necessarily carried out in the stations themselves, could be carried out for an entire region, and where a machine department of real importance could be installed. It appears that Switzerland has taken up this attitude by having the settlements ledgers of each station made up daily by the districts themselves. The available information on this point is, however, very scanty, and merely enables the fact to be mentioned in passing.

## SECTION B.

### Traffic accountancy and statistics.

The accounting and statistical work in connexion with traffic have been grouped together under one head because work of this nature is most generally entrusted to the same department and the two kinds of work are even frequently interconnected.

1. *Accountancy of receipts.* — Accountancy of receipts consists on the one hand in verifying book-keeping entries, this work giving rise to problems which

are very similar for different administrations, and on the other hand of apportionment work of a rather secondary importance for most administrations, but on the contrary of an extensive nature for some administrations.

Disregarding for the moment the rare cases where the apportionment work may have some influence on the other accountancy work, the last-mentioned usually only requires simple appliances, calculating machines, adding machines, and accounting machines.

Calculating machines are used for verifying rates, checking the number of tickets sold (and in this case the use of machines having a double totaliser is an advantage), and for determining quotas.

The verification of forwarding and arrival accounts, receipts, postal orders, etc., involves the totalizing of a very small number of items on basic documents arranged successively in different orders. If, however, it is necessary either to compare directly the departure and arrival accounts, or to compare one with another the individual accounting documents, the principal features of these arrangements is their « bulky » character in the sense that the aim is chiefly to place the documents in a certain order and not to form a large number of distinct batches. Hand-sorting is therefore adopted most frequently. Only one administration (1) (the Netherlands Railways) uses statistical machines for this part of the work. Totalizing for checking purposes only requires adding-listing machines having a small number of counters.

There remain the operations of checking and posting the general station accounts. The operations and some other work (such as the accounts of public administrations) may involve the use of accounting machines properly so-called.

Finally, as regards the proportion of the different kinds of machines, it would appear that the standard equipment of control departments should approximate to that indicated by the French Est Railway Company :

4 Monroe machines,
21 Burroughs,
4 Accounting machines.

It should be noted, however, that many control departments make use exclusively of calculating machines, and adding machines having a small number of counters (Burroughs, Dalton).

Only two railway administrations mention apportionment work justifying a special organisation : the Netherlands Railways (determination of the quotas of rented lines) and the French Railways (apportionment of the receipts of goods traffic exchanged between them; this apportionment is placed in the hands of a common organisation, which also centralises the accountancy of the direct traffic).

The Netherlands Railways arrange for the stations of the rented lines to make returns grouping and totalizing by numbers and stations the receipts from different classes of goods (fast, slow, and cattle) and the numbers of the passengers of the various classes. These returns also contain the quota factor of the rented line as regards goods and cattle and, as regards passengers, they indicate the transit station. It will be seen that for the apportionment of goods, all the central control has to do is to multiply the different receipts by the factors written on the returns, and totalize the partial products.

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(1) It will be seen further on that the Central Inspection of the French Railways also makes use of statistical machines for checking some of the traffic accounts, but this is done in connexion with apportionment work.

Statistical machines are employed in this work by the method of totalized products previously described in Chapter I, and which in this case is fully justified, since the same card may be used to carry out three series of operations.

As regards the passengers, by sorting the cards according to transit station and then tabulating them, the number of passenger-kilometres for each class of ticket due to the rented line may be determined.

The problem of apportioning the goods-train traffic (¹) is much more involved for the French Railways because their stations are not compelled to group the consignments according to the line on their departure and arrival sheets.

The Common Control of these railways is therefore obliged to carry out itself this grouping. For this purpose, up to recently the particulars of every consignment had to be copied into ledgers in separate places according to the lines so as to allow the goods traffic to be totalled quarterly for the different lines.

Owing to the large number of entries (the actual number of consignments amounts to 1 500 000 each year, and the theoretical number is several tens of millions), this procedure involved excessive complications, and the risk of very great and almost undetectable errors.

In providing the Common Control with statistical machines the French Railways took as their object both the improvement of the general accuracy of the work, and its simplification, which was not merely to concern the direct performance of the work and the appliances, but was to be extended, if found possible, to the principle itself of the apportionment.

The first stage of the simplification consisted in devising a despatch card for each consignment, and to carry out the grouping and tabulation per number of consignments per station by means of statistical machines. The despatch card thus devised is used in statistical machines to check the despatch and arrival accounts, a use which not only saves hand-sorting, but does away with the necessity of any direct verification of the perforations.

Lastly, the common control of the French Railways uses a special card for the combined operations of checking the accounts and of apportionment. This card in addition to the data necessary for apportionment, includes the usual accounting data (carriage due, carriage paid, payments, etc.).

The whole of these operations necessitate the cards passing thirteen or fourteen times through the sorting machines, three tabulations, one of which (the apportionment tabulation) consists of nearly 1 000 000 totals.

In the second stage advantage was taken of the facilities offered by statistical machines for comparing the results of the exact method just described with those of an approximate method consisting of grouping, for the purpose of apportionment, not only the number of consignments per station, but the exchanges effected between the zones (¹) of departure and arrival of a certain area, the nature of the exchanges being computed beforehand in such a manner that

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(¹) For reasons which would take too long to explain here, it is only the apportionment of the goods traffic which gives rise to somewhat complex problems for the French Railways.

(¹) When the stations were numbered, this future investigation was taken into consideration, enabling the same number of hundreds to be allotted to each of these zones.

the average apportionment factor remains practically the same. This comparison which the statistical machines enabled to be carried out without much delay, eventually led the French Railways to introduce a much more radical simplification than has just been outlined, and one which will result in reducing the number of items to be apportioned to less than 100 000. It was thought that the preceding remarks had a bearing on the subject under discussion, in that they emphasize the two-fold nature of the service which statistical machines may be expected to give, either as a means of carrying out work purely and simply, or as a means of investigation.

The Common Control of the French Railways sets up 1 500 000 cards per month, and uses 50 punching machines, 10 sorting machines, and 5 tabulating machines.

2. *Commercial statistics.* — The statistics deduced from commercial documents may be either :

— general traffic statistics (general information regarding the nature of the traffic, division of the receipts in several categories, average earnings per passenger or per ton of goods, passenger-kilometres, tonne-kilometres, etc.) ;

— or detailed statistics of a truly commercial character.

The first-mentioned statistics are either obtained directly from the accounting operations, or merely consists in summing up very simple items provided by the stations, which work may be done by adding machines or book-keeping machines.

The determination of the kilometric tonnage (or passenger-kilometres), being based on the tonnage (or passenger) returns sent from station to station and established annually by the forwarding stations, forms in itself a very simple operation, if the precaution is taken of entering the traffic of each kind on a sheet, the sheets being grouped afterwards according to distance.

Those statistics of a truly commercial character, which merely consist in dividing the traffic into a small number of groups according to charge, may also be carried out by similar methods. The growing tendency, is, however, to allot to the commercial statistics a much more extensive role, the object being to be in a position to obtain periodical information regarding the more important streams of traffic, reserving the facility of rapid reference for the others, which implies at one and the same time a very thorough discrimination between the different kinds of goods, as well as rates formulas, and the possibility of isolating the traffic of the stations, or at least of certain zones of arrival and departure. Fairly frequently also commercial statistics are expected to provide information regarding the tonnages of each class of goods sent to different distances.

There seems to be no question of the fact that statistical machines form the indispensable appliance for statistical work intended to furnish information which is at the same time exact and variable.

The use of the machines in question for compiling commercial statistics is actually very widespread (Norwegian State Railways, Czecho-Slovakian State Railways, the French Nord, and the Paris, Lyons & Mediterranean Railways).

The French Railways also intend to allot this third method of use to the despatch card which has been devised by their Common Control, and to which reference has already been made. In this way this organisation would draw-up the statistics of all the traffic exchanged among the French railway systems, each system compiling only the statistics of its own internal traffic. Finally, the Swiss and Belgian Railways are also studying the question of compiling commercial statistics.

The programmes of the various administrations and their methods naturally exhibit fairly considerable differences. The number of goods articles taken separately varies in a large measure. It exceeds 2 000 in the nomenclature already in use on the Paris, Lyons and Mediterranean system; the French systems will probably content themselves with rearranging this nomenclature.

In France the general tendency of the railways already using machines is to reduce the work of the stations to a minimum. The cards are set up either on sight of the despatch notes themselves or according to statistical returns drawn up by the stations without any classification. On the French Nord Railway and on the Paris, Lyons & Mediterranean Railway the code number of the goods is not even mentioned on the basic documents before the cards are punched, and it is the punching machine operators who, referring if need be to memorandums (arranged alphabetically and by groups of rates), conveniently placed on desks, punch these numbers directly. In point of fact such is the assistance rendered by the memory, that after a few months of training these (female) operators only need consult the memorandums for a small fraction of the traffic, and the speed is not more than 10 or 12 % below what it would be if the goods were coded in advance.

In Norway and Czecho-Slovakia the stations are obliged to group the despatches on their statistical statements according to the nature of the goods, and the region, which reduces the number of cards considerably. The coding of the goods is also done by the stations.

## SECTION C.

### Journey statistics.
### Calculation of locomotive running department premiums.

This section deals with all the statistics provided by the Departments dealing with the movements of trains and the working thereof the nature of which will be called to mind by the following list possibly incomplete :

— Kilometres and tonne-kilometres per type of train, per type of locomotive, and sometimes per section of line.

— Gross tonne-kilometres per locomotive (or sometimes per working period of locomotives).

— Kilometres per driver and per locomotive.

(The statistics last-mentioned are used as a basis for calculating running department premiuns.)

The connexion between these different statistics is evident, and the preliminary condition of any rational organisation, is to entrust the compiling of the statistics to a special department (locomotive running department or statistical department common to the different sections). This condition appears to be fulfilled almost always.

In not a few administrations, the compiling of the statistics has been for some time, and still is, entrusted to the divisional locomotive department offices, which are amply supplied with simple calculating machines. The large number of returns, however, based on the items characterising the train journeys (items which appear on the running department reports or journey sheets) is sufficient to show that we are here faced with one of the possibilities of using the statistical machines which « pay » the most, always on the condition that the work previously apportioned to the divisional departments is centralised in a special office.

This actually appears to be the oldest application which has been made of these machines by Railway Administrations.

At the present time, the Swiss Federal Railways, the Belgian Railways, the Netherlands Railways, the Paris-Orleans Company, and the Paris, Lyons & Mediterranean Company work in this way. The Swiss Railways have even incorporated the statistics of wagon movements (¹) for each line of railway in the general programme given at the outset of this section.

Although differing as to detail the methods always involve the making of cards for each simple movement, thus indicating the run of a train or locomotive in which all the running compoments (locomotives, driver, load, etc.), remain constant. The basic documents are completed before the cards are punched by indicating the tonne-kilometres, and the fuel allowance corresponding to the run and to the locomotive. One or two cards are made for each movement according to the extent of the work to be done and the methods (²).

The principal feature of all these organisations is the considerable number of times each card is passed through the sorting machine. Even when two cards are used, the number is usually greater than 25 times per card.,

The organisation of the Paris, Lyons & Mediterranean Company has managed to include on one card all the components of one piece of work, which is, however, very heavy and necessitates 50 passages of each card through the sorter.

The number of tabulations is also very large.

Still, the various administrations mentioned above are unanimous in stating that, in addition to regularity and accuracy, they have been able to effect a considerable saving. Some of them have provided information regarding the time during which the machines are in use, and the cutting down of the staff which enables approximate balance sheets to be drawn up.

The Paris-Orleans Company (P. O.) punches 110 000 cards per month and uses a sorting machine and a tabulating machine for 20 days. They have been able to reduce the office staff from 96 to 66 employees. The annual net saving appears to be about 400 000 fr.

The Belgian Railways who punch 130 000 cards per month, and report 260 hours of sorting and 300 hours of tabulating state they have reduced the staff of the regional departments by 84, giving a net saving of more than a million francs; a considerable fraction of this saving ought to be ascribed. however, to the centralisation of the work itself.

Lastly the Netherlands Railways report a net saving of 25 000 florins.

## SECTION D.

### Location of stock.

The use of statistical machines has also enabled a considerable saving to be effected in compiling the particulars relating to the location of rolling stock.

The Netherlands, the Czecho-Slovakian, and the Belgian Railways, as well as the

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(¹) The Norwegian State Railways compile the same statistics, but only per locomotive.

(²) The Netherlands Railways, extending the use of machines still further, make secondary cards in addition (bonus-cards and allowance cards). These are, however, used much less than the two principal cards.

French Railways through their Inter-Railway Wagon Office, compile in this way their statements of the rolling stock belonging to foreign countries.

The methods employed are very similar :

A card is made out per movement of wagon (arrival, departure, and if occasion arises, the passage from one internal railway system to another (1);

The cards of a given month are put with those cards of the previous month which are not yet done with, and with those of all or part of the following month;

The necessary sorting operations to classify the cards according to dates of movement, railway owning the wagon, and the type and number of the wagon;

Finally the cards are tabulated so as to list the movements which relate to each wagon, one after the other and in chronological order.

Some administrations extend the use of machines still further. After the duration of delays, deductions for demurrage, and hire charges have been written on the first tabulation docket by hand, the information is transferred to the arrival cards, and the tabulation of these cards, after classifying according to place of arrival, provides the statement to be furnished to each administration owning the wagons.

The Czecho-Slovakian State Railways who have 420 000 movements to register each month, and use 10 punching machines, 2 sorting machines (operated together for part of the time) and 2 tabulation machines, state that they have dispensed with 64 employees (of whom 20 were in the transit stations). As regards the Inter-Railway wagon office of the French Railways, registering monthly 450 000 movements and using 10 punching machines, 6 sorting machine, the operation has meant a reduction of 50 in the office staff, or a net saving of 300 000 fr.

The accounts relating to the common user of rolling stock among the administrations of the same country offers similar problems to those outlined above, but they are usually of a simpler nature. There is a smaller number of wagons to be dealt with, and the bases on which the accounts are settled does not require an account to be made out for each wagon. It will be seen that under these conditions statistical machines may cease to be profitable.

In France where the accountancy of the exchanges of stock is confined to the common organisation to which reference has already been made, and only requires a knowledge of the number of wagons of each general type (1) which are daily on each system (this knowlegde implies, as a matter of fact, that the position of each wagon is known), the movements are written on wagon-cards filed according to type and number in card indexes. Not long ago the use of statistical machines was considered and it was found that this would enable a considerable saving on the methods adopted up to the present. It has since been found however, that simple measures of rationalization combined with the use of movable files of the « Roule-class » type would procure a still greater saving (50 employees). The modification of the method has been restricted to keeping the cards in the indexes alloted to the railway owning the wagon, instead of placing them successively in separate indexes according to the railway system on which the wagon happened to be.

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(1) In the case of the French Railways, a separate return has to be drawn up for each system.

(1) Covered, flat, and open wagons.

The cards are filed in about 50 « Rouleclass » indexes 4.30 m. (14 ft. 1 in.) or 3.25 m. (10 ft. 8 in.) long containing 16 000 or 12 000 cards respectively. The total purchase price was not more than 350 000 francs.

This example shows the importance of making every possible investigation in the domain of rationalization pure and simple before proceeding to mechanization in the full meaning of the term.

## SECTION E.

### Wages and pensions accounts.

Accountancy work in connexion with wages consists of :

1. Assembling all the credit and debit items constituting the wages account of each employee.
2. Summarizing all these separate items.
3. Making separate copies of the gross accounts, known as « pay sheets ». Most frequently, one copy is intended for the wages department, one for the paying out department, and a third is intended for cutting up in the perforating machine to provide the separate pay slips handed to each employee.

The pay sheets should also enable the gross payments to be distributed among a certain number of headings.

1. *Items of the individual wages accounts.* — The items of individual wages accounts are generally entered first of all on individual pay accounts (or sometimes on previous wages statements), but while as regards the employees on the administrative side these items are obtained directly from the employment registers and the attendance sheets, the wages of the men employed in the Locomotive Running Departement include bonuses which are compiled in the somewhat complicated fashion already described.

The accounting of the individual wages of the persons employed in the workshop (locomotives, rolling stock and permanent way) is also subject to special variations, due not merely to the method of making up the wages (bonuses, jobs, etc.) but also an account of their connexion with the fixing of the costs. The desire on the part of some administrations to fix strictly the cost of each job leads them, in fact, to record separately for each distinct job the length of time each workman is employed (even distinguishing if necessary the nature of the hours worked). In this case it becomes necessary to totalize the times stated on the different work tickets, after having arranged them in order of workmen.

These operations are generally carried out by handsorting and simple adding machines. When, however, the cost accounts are very complicated, it may become necessary to have a card punched in agreement with the work tickets. This is done by the Netherlands Railways. This administration even extends the use of statistical machines still further by making a card for each item of the wage (bonuses, allowances (1), etc.). All these cards, after being brought together and arranged in order of workmen provide, after a single tabulation, all the *credit* items of the wage.

Other Administrations (Paris, Lyons & Mediterranean Company) merely make use of cards giving the time allowed for each job. These cards are afterwards used to bring out the times charged to the jobs.

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(1) The cards corresponding to those allowances which do not vary, are of course also used in making up subsequent accounts.

2. *Totalizing the items of individual wages. Preparing the pay sheets.* — Once the various items of the individual wages accounts have been collected, the problem of totalizing and posting them in pay sheets is practically the same for the different departments. These two operations have given rise to a very large number of centralized and more or less mechanized organisations. It was thought that it would be of interest if a few particulars were given regarding the more important (see table hereafter).

These organisations have some points in common, but differ fairly widely in others.

All involve the posting of the different wages items in an order enabling the subtotals of the amounts to be deducted for the pensions fund and the sums liable to income tax to be obtained. The wages of each employee may be totalized on the pay sheets either across or vertically but the last-mentioned method is becoming more frequent owing to the very large possible number of wage items.

As to machines, the organisations in question prefer two distinct types : in the first (the more common) the individual items are totalized and posted on the pay sheet in two consecutive operations, and consequently they only necessitate the use of adding machines having two counters. These two consecutive operations afford a mutual check as to the correct working of the counters. They may even provide a full guarantee against errors in reading if the operator is obliged, as in the case of the French East Company, to make the second summary from the basic documents themselves.

Organisations of this type are oftener than not completed by addressographs for listing the names and numbers of the employees.

Organisations of the second type make use of accounting machines having a large number of counters, vertical and cross adding being performed simultaneously. The final agreement of the operation provides a check on the proper working of the counters. There remains the necessity for checking the items of the pay sheet with the basic documents. These organisations ought to be able to dispense with the use of addressographs, but by using them the work is speeded up considerably.

The particulars of the speed, as regards the organisation of the French Est Company (1st type) and that of the Paris-Orleans Company (2nd type), enable one to make an interesting comparison. The 12 machines of the French Est Company (6 Sundstrand machines having 1 counter, and 6 Burroughs Duplex machines) are used for *65 hours* per month, and summarize 36 000 individual pay-accounts and 3 600 columns of totals, equivalent in all to 3 500 000 figures. Referred to the number of individual pay-accounts the speed is 40 an hour (1). The 12 Mercédès machines of the Paris-Orleans Company, employed each on an average for 130 hours per month, make up 41 000 columns of pay-accounts and summarize 8 000 columns, together equivalent to 4 000 000 figures. Referred to the number of individual pay-accounts the speed is only 27 per hour. In this case, however, the organisation is of recent formation, and only half the employees are trained operators, whose speed is 37 per hour. On the other hand the Paris-Orleans have found it possible to increase

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(1) Several administrations give a speed of 50 employees' pay-accounts per hour as normally obtained with electric Sundstrand machines. However, the number of figures per employee is, perhaps, not so great.

| *Name of Administration.* | *Degree of centralization.* | *Total number of employees whose wages are dealt with by machines.* | *Type of machine.* |
|---|---|---|---|
| Czecho-Slovakian Railways. | One for every local manager's office for all departments. | 112 000. | Elliott-Fisher and Underwood « Book-keeping » working in pairs for a fortnight. |
| Paris-Orlean Railway. | One organisation for the whole of the Operating and Permanent Way Departments. | 40 000. | 12 Mercédès machines working a fortnight in every month. |
| French Nord Railway Company. | Central Operating Department. | 31 000. | 16 Dalton machines. |
| | Divisional Permanent Way Departments. | ? | Elliott-Fisher machines. |
| Netherlands Railways. | Central Traffic Department. | 13 000 (several wage tickets are prepared each month. | 5 electrical Sundstrand machines (one fortnight per month) and 1 addressograph. |
| | Central Locomotive Running Department. | 9 000 (several wage tickets are prepared each month). | 6 electrical Sundstrand machines, 2 adding machines, 1 addressograph. |
| | Rolling Stock Department. | 5 000 (several wage tickets are prepared each month). | Ellis machines. |
| Belgian National Railway Company. | Central Operating Department. | 22 000. | Borroughs Duplex machines. |
| | Divisional Permanent Way Departments. | 20 000. | Elliott-Fisher machines. |
| French Est Railway Company. | Central Operating Department. | 36 000. | 6 Sundstrand adding machines.<br>6 Borroughs Duplex accounting machines. |
| Société des Transports en commun de la région parisienne. | All employees. | 28 000. | Remington machines. |

the speed by 30 % by using an addressograph to list the headings (names and numbers). Under these conditions the speeds obtained by the French Est and Paris-Orleans Companies may be regarded as quite comparable.

It remains to be stated that the cost of equipping the 2nd type of organisation is much greater than that of the 1st type. The selection of this type may, however, be justified (and that is precisely the case of the Paris-Orleans Railway) if the whole of the work which may be allotted to the machines is taken into consideration, it being borne in mind that the preparation of the pay-sheets only requires the use of the machines for about half the month.

The feature of the organisation of the Paris-Orleans Railway just described which, it seems, ought to be particularly noted, is the considerable saving in staff resulting from the concentration of the departments and the use of machines. The total saving is not less than 90 employees.

At the French Est Company, where centralisation was effected before the use of machines, mechanization alone has enabled 19 employees to be dispensed with, corresponding to a real saving of 440 000 francs.

In conclusion mention may be made of the use of accounting machines by the Société des Transports en commun de la Région parisienne for keeping up to date the individual cards showing the position of each employee with regard to the pensions fund. The machine transfers and totalizes the deductions (as recorded on a copy of the pay-sheet) simultaneously on the individual cards (which can be taken out by means of a special device and on a sheet intended for totalizing the deductions by departments. By comparing the totals on the sheet with those of the accounting documents the accuracy of the operation of transferring the deductions and of the accountancy work itself can be checked.

On the other hand the notification of the pay departments of amounts due for pensions may also give rise to the preparation of account sheets by the same methods as used for pay sheets.

## SECTION F.

### Stock accounts.

The accountancy of the stores consists in keeping the day-books and ledgers, the latter being divided into as many folios as there are articles, the number of which is generally very considerable; the daily entries should be checked.

It is generally considered (¹) that the most satisfactory method is to make out cards for each folio of the ledger, the cards being kept in a suitable card index.

If the stock cards have to be kept up to date as regards quantity only and not as regards value, a very satisfactory solution is to use accounting machines or even simple adding-listing and direct subtraction machines. In the two cases the statements should be checked by means of a stock book.

If the stock accounts have to be made up regularly as to both quantity and value, and if the movements to be recorded daily are sufficiently numerous, the use of a Burroughs-Moon machine is indicated (the central store of the Paris-Orleans Company at St. Pierre des Corps, which until recently made use of Smith and Monroe machine, is expected to effect a saving of 5 employees by using 2 Burroughs - Moon machines).

The Netherlands Railways mention one application of statistical machines in their permanent way department stores which comes within the scope of this section.

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(¹) The Belgian Railways, however, use statistical machines at their central stores at Malines.

This organisation fulfils a twofold purpose; the rapid determination at the beginning of each month of the state of all the partial or general stocks on the railway system, and secondly the utilization of the daily particulars received regarding the movements of stock, for preparing a certain number of statistical statements concerning the work carried out on the permanent way.

For this purpose all the movements of material from one stock to another are alloted two cards, one card showing an increase of the stock B and the other a decrease of the stock A. A card is also allotted to every purchase or issue (sale or incorporation in the permanent way).

This organisation uses about 50 000 cards per month; 6 punching machines, 2 sorting machines, and 1 tabulating machine are used.

## SECTION G.

### Cost accounts.

The cost accounts are connected with the wages accounts and stock accounts; all these accounts afford a mutual check on each other.

It has been seen that the Permanent Way Department stores of the Netherlands Railways, and to some extent the Paris, Lyons & Mediterranean Company make use of statistical machines for the ac-accountancy work in connexion with the cost of labour.

The usual procedure, however, is to post on « job » cards and totalize successively the work tickets and the stock slips. The hours of work should be distributed among the various workshops so that, once a piece of work is completed, the average hourly wage and the proper proportion of the general expenses may be allotted to them. The cards may be posted by means of simple adding machines, but each job should be allotted a principal card and as many sub-cards as there are workshops affected by the distribution. It is much simpler to make out a single card by using the Burroughs Multiplex machine or accounting machines.

Some Permanent Way Departments (Belgian Railways) requiring the exact costs, transform into expenditure the particulars on each separate docket, and make use of the Burroughs-Moon machine for this purpose.

## SECTION H.

### Various problems affecting general accounting work.

The number of accounting machines, used by the financial departments is not very great, and very little information is available regarding their use. It does not appear that the drawing up of accounts on cards is as yet very widely spread. The only application which can be mentioned in this connexion is that of the Permanent Way Department of the Belgian Railways (in which the accounts of the credit and debit allocations are prepared by means of Elliott-Fisher machines) and the Norwegian Railways.

The general accounting office of the French Nord Railway uses 16 Burroughs adding machines for registering all the payments made by the pay-officers (to employees, stations, departments, banks, treasury, etc.).

Finally the general accounting office of the Netherlands Railways proposes to use statistical machine and perforated cards for posting the monthly statements of the receipts and payments for every pay-office and item. The final check on the operations would be obtained by comparing the results of the tabulation with the totals of the day-books in which the various items of receipt or payment are entered as they are made. It will certainly be very interesting to follow this experiment. It should be noted, however, that the method it is intended to use obviously possesses the disadvantage of not allowing the different accounts to be followed day by day.

## SECTION I.

### Various remarks regarding the organisation of the mechanization.

*Concentration of the work.* — Concentration of the work facilitates supervision and organisation and enables the machines to be put to a more continuous use.

The previous remarks show that, in effect, the concentration, in a single office, of work of *the same nature* and of some magnitude, affecting the various local departments of a large service (which might be termed vertical concentration) takes place fairly frequently at the same time as mechanization, of which it is regarded almost as an essential condition.

It has also been seen that offices have been equipped for making up the pay-sheets of *several large departments.*

The form of cencentration consisting in entrusting to the same office *different* kinds of work affecting several departments (which might be termed horizontal concentration) is still, however, quite exceptional.

As regards accounting machines, the organisation of the Paris-Orleans Company, the main object of which is to prepare the pay-sheets, appears to be the only one to have achieved this double form of concentration. Owing to the different kinds of work (particularly relating to commercial statistics) which are outside the main programme of work, it is possible to use the machines continuously throughout the month, whereas the delays in preparing the pay sheets would reduce the period of use to a fortnight.

There can be no doubt, however, that, as regards statistical machines, the installation of a large office appears to commend itself most if the machines are to be put to good use and their application is to be extended. Here again, however, the organisations are generally restricted to carrying out the work of a single department. Moreover, judging by the information provided, in some cases the machines are utilized in what is certainly an unsatisfactory manner.

The Paris, Lyons & Mediterranean Company appears to be the only administration which so far has organised a central statistical machine department common to all the departments of the Company. It is believed that this example is worth following.

*Studies in rationalization and mechanization.* — It has also been considered of interest to note the decisions taken by some administrations (Netherlands Railways, Paris-Orleans Company, French State Railways) to entrust to a specialized organisation the study of the rationalization and mechanization of accountancy and statistical work. The similarity of the various problems which arise, their frequent overlapping, and the profound knowledge of mechanical methods, always of a progressive character, which such a study demands, lead one to believe that considerable advantage would actually be derived by creating such an organisation, intended in a way to act in an advisory capacity to the different departments on questions of this nature.

*Measures to be taken in order to derive the best use from the machines.*— Seeing that a machine represents a capital of some importance, every effort should be made to ensure that it is used as much as possible. With this object in view an endeavour should be made to facilitate the summarizing of the basic documents by an appropriate arrangement of the matter. The data to be posted by machines should be grouped in the same order as the operations to be carried out on the machines.

The operator should be relieved of all accessory work. For instance, if the operations are to be carried out on adding or book-keeping machines the basic documents are fixed beforehand on a table or revolving drum and are partly covered up so as to reveal only the columns or lines of figures required. There are devices in existence which, as the operation is carried out, cause the drum to revolve in such a fashion that the number to be read off is always indicated by a pointer. In this way an appreciable increase in speed is obtained.

Lastly, it is generally profitable to grant the operators a speed bonus which would take into account the value of the machine and the effect which the operator can exert on the speed. The bonus would be subject to deductions in the case of mistakes.

## CHAPTER III.

### Conclusions.

The very numerous details which by the nature of the subject, constitute the report given above, cannot be summarized easily in the proper meaning of the term.

We propose, therefore, that the Congress should bear in mind and approve a few statements or recommandations of a very general character which appear to us to be the most essential :

I. — The object of improvements in accountancy and statistical work is most frequently the reduction of expense. Other considerations, however (extending the possibilities of investigation, delays in carrying out the work, the desire for accuracy, etc.), may also justify modifying the methods.

The saving effected in carrying out accountancy and statistical work is obtained by the combined use of measures of rationalization and of mechanization, the importance of the former often preponderating.

As regards the selection of appliances it is recommended that every endeavour should be made to effect the lowest cost, taking all the items into account, by the simplest possible means.

II. — The character of the study of the rationalization and mechanization of accountancy and statistical work appears capable of justifying the formation, in each administration, of a special organisation acting in an advisory capacity to the different departments on questions of this nature.

III. — The concentration of the work in offices of some size often constitutes in itself the essential condition for the use of the machines (in this way it seems that the extension of this use for station work is bound up with the possibility of transferring to certain central stations some of the accounting work of the less important neighbouring stations, a possibility which deserves closer attention).

Very frequently the concentration in a single office of the same work affecting the different local branches of a departmen, even though it may not form the sole condition for the use of machines, is admitted to be advantageous, the supervision and utilization of the machines being all the better assured, the larger the offices.

To ensure that the machines in an office so centralized are in continuous use, it may be necessary to entrust the office with different kinds of work, affecting or not affecting the same branches, in other words, to effect at one and the same time vertical concentration and horizontal concentration.

The grouping in a single office, for every large department, of all the work which can be carried out by statistical machines appears to be highly commendable, in order to ensure that the machines are put to good use and to enable that use to be extensed. Some administrations have even equipped a single office for the whole of their departments.

IV. — Most frequently, the use of statistical machines should not be considered unless it is possible to combine among them several accountancy or statistical operations, ensuring a satisfactory utilization of the cards, and necessitating a very large number of sortings and tabulations. It is expedient, moreover, in all cases to endeavour to strike an exact balance between this solution and simpler solutions.

The use of the said machines is, however, recommended *a priori* when it is a question of the possibility of very diverse and extensive investigations (a form of problem of which commercial statistics appears to be the prototype).

V. — It is very often profitable to compare the results given by accounting machines with those of simple adding machines, the respective advantage of the two types of machine depending upon the individual particulars of the programmes of work, especially the greater or lesser density of distribution of the numbers, the existence of minus items, the average number of lines in the statements to be prepared, etc.

VI. — The use of ticket machines in busy stations, especially suburban stations, appears capable of procuring considerable advantages, and this question demands further examination.

The question of making use of franking machines placed at the disposal of certain forwarding firms or agencies, as well as the use of this machine for issuing contract tickets also deserves examination.

*(July, 1929.)*

[ 385 .524 ]

# REPORT No. 2

## (Belgium, France and their Colonies)

## ON THE QUESTION OF THE CO-OPERATION OF THE STAFF TOWARDS INCREASED EFFICIENCY AND ITS PARTICIPATION IN THE PROFITS (SUBJECT XV FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1),

By Mr. SOULEZ,

CHIEF ENGINEER, HEADQUARTERS OF THE OPERATING DEPARTMENT
OF THE FRENCH NORD RAILWAY,

and

Mr. BLOCH,

CHIEF ENGINEER, ROLLING STOCK AND WORKSHOPS DEPARTMENT
OF THE PARIS-ORLEANS RAILWAY.

## General Remarks.

In the second part of the 19th century, when the transformation and concentration of industrial and commercial undertakings became more marked, the problem of increased output became very urgent in all countries.

Many formulæ dealing with payment of wages have been invented and applied in turn, all of them having as their object the establishment of a satisfactory balance between the needs of production, that is to say the increase of production and the reduction in cost price, and the claims of the workers which, to only quote the principal, have in turn been : increase in pay, reduction in the hours of work, regularity of employment guaranteed by insurance against unemployment, sickness and incapacity, the increase of pay in terms of the cost of their families, and finally more recently benefit of a pension to which the master contributes with an annual holiday with pay.

From observations made, it soon became evident that payment solely based upon the hours of duty would not form a proper solution of the problem, and that in order to increase the output it was necessary to interest the employee in the production by paying him a supplementary salary calculated upon his individual output.

The various formulæ invented have therefore given to the staff a supplementary payment either by means of bonuses granted by the employer as he thinks proper or by the payment of premiums.

Amongst the systems of payment based upon output, can be quoted :

1. *Task work*, which diminishes the

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(1) Translated from the French.

overhead charges but has no effect upon the unit cost price as the production grows;

2. *Piece work*, which has the same drawback as task work and does not oblige the workman to make the best use of the tools or materials at his disposal.

Furthermore, task work as piece work can sometimes cause the workman to make an abnormal effort which he cannot maintain for a lengthy period and which consequently can upset the regular running of the undertaking. In addition, any error in fixing the piece prices is either to the disadvantage of the workman or the master; it is consequently necessary to revise the rates at intervals and this leads to disputes and difficuties.

As a result the masters have endeavoured to substitute, for the above two methods, the following :

1. *Premium work* (Rowan, Halsey and Atkinson systems) in which the workman does not receive the full price for each piece produced, but instead a premium, added to the guaranteed hourly rate : the workman is paid part of the saving resulting from the economy of time he has made, the other fraction recompensing the expenses incurred by the management in improving the tool equipment and the conditions under which the work is done. The system also most often carries with it penalties for bad work, spoilt material, or insufficient output.

When applying the system the time allowed for the manufacture of each piece is determined either by timing with a watch, or from the result of previous work. As the premium decreases after a certain output, while it stimulates the efforts made by the workman it does not incite him to overwork, and thereby avoids any falling off in the quality of the work or wastage of parts and materials.

In certain branches of industry and commerce, the premium or commission is based upon the output, upon the receipts, or upon the total business done by the receiver, the seller, the office or section of the undertaking.

In the systems of remuneration analysed above, the additional salary corresponds to the exceptional efforts of the workman. It is obtained by a formula previously known and is paid at once at the same time as the salary properly speaking.

Another idea has come very much to the fore : the need for interesting the staff in the consumption of consumable stores as a result of which premiums are paid for economy and investigations made into all causes of bad working or of damage.

All these kinds of premiums fall into the same class and have as their object the encouragement of the staff to carry out conscientiously *their daily personal work;* but it was logical to go further and to interest the staff in the general running of the business by making it participate to a certain extent in the profits of the business employing it.

In the systems of profit sharing the staff is paid a part of the net earnings at the end financial year.

The proportion of the earnings to be distributed is fixed by the head of the undertaking, the proportion varying according to the undertaking, being by equal parts or with the introduction of one or several factors, such as total of the salaries, length of service, grade, importance or value of services, family charges, etc.

In some cases the distribution is by individuals, the amounts being paid in money or capitalised in an individual book;

in other cases the share is collective, its amounts going to a collective fund for sick benefits, old age, or pensions.

Profit sharing has only been introduced in relatively few cases in France and Belgium. In France participation is moreover prescribed by law :

1. In manufacturing companies placed under the law of the 18 December 1915;
2. In mining concessions or workings granted after promulgation of the law of the 9 September 1919.

In other undertakings, to the number of about 150 in France and 50 in Belgium, participation in the profits is entirely due to private initiative. With few exceptions, so far as can be judged from the replies we have received, it appears that sharing in the net profits has only had a slight influence upon the amount of work turned out in the industry.

Profit sharing, moreover, has not prevented certain difficulties arising, and these have not facilitated the extension of its use. It does not in fact make it possible to proportion the share due to the workman to his individual output, and above all his efforts are not immediately rewarded.

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It should not however be forgotten that the method of payment and in particular the institution of premiums or gratuities for good output only forms one of the factors in improving the production given by the labour employed because the organization of the work and the use made of the labour are factors of at least equal importance.

In fact if the workman as regards his trade is so placed that he finds himself supplied with work regularly, and supervised in his craft by chiefs who really know their business, and who are rather advisers than controllers, and if he feels himself in brief, the centre upon which the whole organization converges he works well, carried forward by the task itself and encouraged by the feeling that his work is of value.

Furthermore, the professional feeling of the workman, as well as his personal interest, also constitute factors of the first importance as regards output, which have to be taken into account. Moreover the rational organization of an undertaking ought to be investigated before questions of remuneration, not only on account of its prime importance but also because these latter very closely depend upon the former, whereas the contrary is not the case. As a matter of fact, if a workman is so paid that his earnings depend upon the amount he produces, he will see, for reasons outside his control, his salary suffer considerable variations, according to the conditions under which his work is organized. A method of payment which would be satisfactory under certain conditions would be inacceptable when the work is organized in another way. It is then logical to investigate and to improve the organization of the work in a methodical manner, and to obtain the highest output that these improvements make it possible to obtain before making the workman interested in his production. Once this procedure has been realized the latter will receive a fair remuneration founded upon stable and definite conditions of work and any variations in it will depend solely upon his own activities.

An examination into rational methods of organization as a whole does not enter into the scope of this report. The résumé above has as its object to place the question of remuneration in its true place, that is to say, to show that it only forms a part of the greater and wider problem of rational organization.

* * *

According to the plan of our questionnaire, our investigations will be divided into two parts, as shown below :

**First part.**

*Steps taken to improve the individual or collective output.*

*Chapter I.* — Premiums and gratuities common to employees of all Departments.

*Chapter II.* — Premiums and gratuities granted to employees in the Operating Department.

*Chapter III.* — Premiums and gratuities granted to men in the Chief Mechanical Engineer's Department and in the Locomotive Running Department.

*Chapter IV.* — Premiums and gratuities granted to men in the Permanent Way Department.

*Chapter V.* — Measures affecting temporary labour or contractors employed by the Railway Company.

*Chapter VI.* — Premiums and gratuities : special cases.

**Second part.**

*Chapitre VII.* — Measures taken to interest the staff in the general financial results of the undertaking.

# FIRST PART.

## CHAPTER I.

## PREMIUMS AND GRATUITIES AVAILABLE TO THE STAFF OF ALL DEPARTMENTS.

### SECTION No. 1.

### Premiums and gratuities intended to recompense personal merit, long service, keenness, devotion to duty, initiative, etc.

**A. — Personal merit.**

The Staff Agreement for the whole of the great French Railway Companies provides :

1. That at the end of each year, each employee shall receive a certificate of merit marked from 0 to 20 by taking into account his professional value, his behaviour, his work, and the difficulties of the post or posts held during the year.

This certificate is completed by a general appreciation of the ability of the employee.

The certificates after being examined by the classification committees including representatives of the staff and approved by the Director authorise the grant of seniority bonuses, and the annual gratuities considered below :

2. That the normal period laid down to pass in a given grade from one scale to the next higher can be shortened by seniority bonuses or on the contrary be increased by delaying the promotion as a punishment for serious faults.

Seniority bonuses are distributed each year to the most deserving employees who have not reached the maximum scale of their grade. They are equal to 1, 2, 3 or 4 months pay.

— The number of employees benefiting from seniority bonuses cannot exceed 1/3 of the number of employees in the grade;

— The number of seniority bonuses of more than two months, cannot exceed 1/6 of this number;

— The number of bonuses of more than one month cannot exceed 1/4 of this number;

— The number of bonuses of four months, as well as those of one month, ought not to exceed 1/4 of the total number of seniority bonuses granted.

3. To each section of each grade corresponds a standard gratuity, 4 degrees of augmented gratuities, and 4 degrees of reduced gratuities.

The standard gratuity is a percentage of the annual pay (from 1.5 % for a labourer, a shunter, a platelayer, placed on a scale 1, to 14 % for the Divisional Inspector, the Assistant Engineer, Shed Superintendant, or Head of a section, or a first class Station Master placed in scale 18.

The 4 degrees of reduced gratuities represent respectively 5/10 (R.4), 7/10 (R. 3), 8/10 (R. 2), 9/10 (R. 1) of the standard gratuity (N.); the 4 degrees of augmented gratuity represent respectively 11/10 (M. 1), 12/10 (M. 2), 13/10 (M 3.), 14/10 (M. 4), of the standard gratuity.

A gratuity is only paid to those employees obtaining a certificate of merit of at least 8.

Augmented gratuities can only be given to employees whose certificate of merit is at least marked equal to :

| | | | |
|---|---|---|---|
| 13 | for the | value | M. 1. |
| 15 | » | » | M. 2. |
| 17 | » | » | M. 3. |
| 19 | » | » | M. 4. |

Furthermore, unless authorised by the Director and for the scales 1 to 14 included :

— the total number of augmented gratuities cannot exceed 1/2 the number of employees in the grade;

— the accumulative number of the gratuities M. 2, M. 3 and M. 4 cannot exceed 3/8 of this total;

— the accumulative number of gratuities M. 3 + M. 4 cannot exceed 2/8 of this total;

— the number of gratuities M. 4 cannot exceed 1/8 of this total.

The employees whose certificate of merit is marked less than 12 receive a reduced gratuity.

In addition, the gratuity can be reduced or suppressed, either as a disciplinary measure by the Head of the Department or by the Director, or in proportion to the absences during the year.

### Société de Transports en Commun de la Région Parisienne.

Premiums known as good service premiums are awarded to certain members of the staff (Engineers, Inspectors, Technical staff, Drawing Office staff, Higher staff in various works) to recompense personal merit.

The amount allotted to each employee is in proportion to the work done by him and to the results he has produced.

**State Railways (Algerian Lines), Tunisian Railways, Sfax to Gafsa Railway, Konakry to the Niger Railway, French Dahomey Railway Company, Upper Congo to the Great Lakes Railway, Landes Railway, Deux-Sèvres Departmental Tramways, Indre Tramways, General Light Railway Company (France).**

Annual gratuities paid in accordance with the formulæ in use on the great French Railways.

### B. — Long service.

**Belgian National Railway Company.**

The Belgian National Railway Company grants gratuities for length of service under the following conditions :

| — | Employees (excluding officials and workmen on the staff). | Other workers. |
|---|---|---|
| After 35 years of good and loyal service. . . . . . . . . . . | 300 fr. | 150 fr. |
| — 45 — — — . . . . . . . . . . . . | 450 — | 225 — |
| — 50 — — — . . . . . . . . . . . . | 600 — | 300 — |

### C. — Keenness and devotion to duty.

**Belgian National Railway Company.**

This Company grants in exceptional cases gratuities of from 5 to 150 fr. for presence of mind, devotion to duty, etc., in preventing accidents, fires, or during such happenings.

In addition the staff of the Company is induced to take an interest in discovering broken or cracked rails by the grants of the following gratuities :

| Broken rails. | | Cracked rails that had to be replaced. | |
|---|---|---|---|
| Main line. | Other line. | Main line. | Other lines. |
| 15 fr. | 6 fr. | 21 fr. | 9 fr. |

The discovery of boxes running too hot is rewarded by a gratuity of 15 fr., and the discovery of any obstruction on the line a gratuity of 9 fr.

The discovery of anyone throwing missiles is awarded a gratuity of 60 to 150 fr., and the discovery of theft, malfeasance, etc., to an award of 15 to 150 fr.

### Great French Railway Companies.

The Staff Agreement applicable to all the great French Companies, makes provision so that in order to reward an act of devotion to duty and of keenness, the Director can by a reasoned decision :

*a*) insert the names of the employees in the working notice of the Department or of the system;

*b*) grant special gratuities to the employees;

*c*) either during the year or when getting out statements of good service insert straight away on the table, at the position he has selected, the names of those men who have specially distinguished themselves under difficult conditions.

By reason of the exceptional character of these recompenses, the manner of granting them is not as a rule laid down in any regulation, except in certain special cases, in which the following rules are applied :

### Discovery of broken or fissured rails.

### Alsace-Lorraine Railways.

| — | | In the open. | In tunnels. |
|---|---|---|---|
| Main lines. | Breakage or fissure clearly visible. . . . | 20 fr. | 30 fr. |
| | Breakage or fissure difficult to see . . . | 30 — | 40 — |
| | Breakage or fissure of a whole fish plate. | 10 — | 17.50 fr. |
| Other lines. | Breakage of a rail . . . . . . . . . . . . | 10 — | |
| | Breakage or fissure of a whole fish plate. | 10 — | |

No gratuity is given when the discovery of the breakage or fissure is made by a man in the Permanent Way Department walking over a section for maintenance purposes or when inspecting the section of the line concerned.

### French Est and Midi Railways.

Rail in the main line in the open 25 fr.

Rail in the main line in tunnel 37.50 fr. with increases up to 12.50 fr. depending upon the difficulty of discovering the defect.

Rail on secondary line 12.50 fr.

The gratuity is only paid when the employee has taken the necessary steps as regards safety. It is not paid when the defect is discovered when repairing, relaying, or maintaining the line.

### French Nord Railway.

| — | Employees in grades 2 to 7. | Employees in grade 1. |
|---|---|---|
| Rail broken on main line | 25 fr. | 30 fr. |
| Rail broken on shunting or holding siding line | 15 — | 20 — |

### Paris, Lyons & Mediterranean Railway.

The discovery of broken or fissured rails gives rise to the grant of a gratuity varying from 12.50 fr. to 50 fr. and depending upon the circumstances and difficulties of discovering the defect.

### State Railway lines in Algeria.

| | |
|---|---|
| Discovery of a broken rail on a siding | 7.50 fr. |
| Discovery of a breakage or fissure in the open and on the running line | 12.50 fr. |
| Discovery of a breakage or fissure in a tunnel | 17.50 fr. |

## Other acts of vigilance and devotion to duty.

### French Nord Railway.

Special gratuities varying from :

— for reporting a box running hot, 10 to 15 fr.;

— for calling attention to defective loading, 20 to 75 fr.;

— for reporting wagons on chains, 25 to 40 fr.;

— for reporting a train or rake of wagons broken away, 75 to 150 fr.;

— for reporting or removing obstructions on the line, 30 to 100 fr.;

— for steps due to the presence of mind of a signalman or a driver by which a collision or run into is avoided, 75 to 500 fr.;

— for saving a passenger, 75 to 500 fr.;

— for reporting a fire, 25 to 250 fr.;

— for apprehending thieves, 15 to 300 fr.

### Paris, Lyons & Mediterranean Railway.

The amount of the gratuities is in principle fixed as follows :

— Reporting a signal lamp out, or a signal working wrongly, 10 fr.;

— Stopping a train in time before an obstruction or a person in danger, 20 fr.;

— Reporting defects or various incidents (open door on a train, fire, etc.), 10 fr.;

Reporting defects or incidents affecting the safety of trains (hot box, vehicle on fire, etc.), 20 fr.;

— Collecting and handing in parts belonging to stock found on the line, about 10 % of the value of the parts recovered.

## D. — Initiative.

### Belgian National Railway Company.

The Company grants gratuities the amount of which varies according to the importance of the savings realized to those employees who, by their initiative and exceptional keenness, have contributed to the successful carrying out of measures resulting either in an improvement of the service, or reductions in the operating costs.

The Company expects the Heads of Departments to foster and encourage all initiative in this direction shown by their subordinates.

### Société de Transports en Commun de la Région Parisienne.

In order to develop the spirit of initiative of its employees, a permanent competition has been organized in order to enable each one to put forward his ideas on the subject of the improvements which could be made in the fixed plant equipment, rolling stock, or operating methods.

The schemes are examined by a special Committee which, when justified, recommends the suggestion to be tested and the grant of special gratuities.

### Paris-Orleans.

All junior officials are invited to put forward all possible suggestions likely to improve the equipment, the methods of carrying out the work, or the handling of goods and the output or to improve details of the rolling stock, to make the service more economical and more regular, or to reduce administrative work, etc.

These suggestions are sent in in writing and all are answered.

The suggestions used are rewarded by grants calculated according to the total of the savings effected.

Although it is part of the normal duties of the higher employees to endeavour to improve the methods of doing the work, provision is none the less made to grant them special awards when the suggestions received from them exceed the level corresponding to the usual duties of the employees.

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## SECTION No. 2.

## Premiums and gratuities reserved to the supervising or management staff, based upon the results obtained by such staff in the management of the works to which they belong.

### Belgian National Railway Company.

#### 1. Locomotive depots.

The Head of the workshops, the chief foreman, the foremen, leading machinists, chargemen and examiners, receive a collective monthly premium distributed among those concerned in proportion to coefficients which vary with the positions occupied.

The amount of this premium is based upon the savings of fuel and oil, as well as upon the total of the premiums for keeping their engines in good order obtained by the drivers of the shed.

The table on pages 2548-2549 gives the method of calculating this premium.

#### 2. Main workshops.

#### a) *Locomotives.*

The management and supervisory staff of the main locomotive workshops benefit by a collective monthly premium divided amongst those concerned in proportion to coefficients varying with the duties and the numbers of days at work. This premium is fixed according to a scale which takes into account the three following factors :

— Number of locomotives turned out;

— Mechanical complications of these locomotives;

— Extent of repairs carried out.

### b) *Wagons.*

The management and supervisory staff of the workshops benefits by a monthly collective premium distributed in the same way as in the case of the management staff of the locomotive workshop.

This premium is based upon the average time taken for repairs carried out in the shops, upon the number of wagons multiplied by 10 hours repaired, and upon the number of effective hours of work in the shop, these three elements being compared with the results obtained in each of them in 1926.

The table on pages 2548-2549 gives the method of calculating this premium.

### c) *Carriages.*

The management and supervisory staff of the carriage works benefits by a premium similar to that granted to the staff in the main wagon workshops. The factor relating to the time taken for the repairs does not however enter into the calculations of the premium.

### a), b), c) *Staffs responsible for carrying out the organization in the main workshops.*

The premium allocated to these employees is based upon the increase in output obtained in the shops since 1926.

The table on pages 2548-2549 gives the method of calculating this premium.

## Great French Railway Companies.

For the whole of the great French Railways, the staff agreement provides that at the end of each quarter a management premium shall be granted to the staff controlling the workshops under the Chief Mechanical Engineer and the Locomotive Running Department; this premium can be augmented or reduced according to the quality of the work done and the results obtained by each man.

On certain Companies, this premium varies without any formula being applied; on others, formulæ are used in which are included factors the value of which depend upon the proper management of the work.

Although no management premium is provided by law for the charge hands and the assistant charge hands, most of the great Companies have decided to let these men share in such premiums as those paid to men of higher grades.

## French Est Railway.

### a) *Locomotive depots.*

The management premium granted to the superintendent, assistant superintendent, and foremen, of the depots, inspectors, assistant inspectors, and leading drivers, varies in accordance with a formula, which takes into account any work done beyond carrying out the usual duties, the profitable use made of the enginemen, the output of the depot shop, the proper use of unskilled labour, and the savings made in the amount of materials used.

The table on pages 2550-2551 gives the formula used.

The total of the premium so obtained may be reduced for untoward incidents, delay in getting a pilot engine ready, or for any professional mistake. They are augmented in the event of any pilot engine being made available very quickly.

The chargemen and assistant-chargemen at the locomotive depots share in part of the collective premium allocated to the workmen based upon the total time allowed for the whole of the work shown on the price lists (see chapter III, section 3). The amount paid to each of these men is in proportion with a coefficient varying with the grade.

### b) *Repair shops and running repairs posts.*

Management premiums for superintendents, assistant superintendents, foremen, charge hands, and assistant charge hands of the maintenance gangs, are calculated by the formulæ shown on the table on pages 2550-2551, which takes into account the total time allowed for repairing the wagons, the total time taken to do the work, the total of times not shown on the lists.

### c) *Main workshops.*

The chief foremen and foremen benefit by a management premium which varies with the proportion of the time spent on work included in the lists in relation to the total time taken by the men in the section of the workshop the supervisor controls.

The charge hands and assistant charge hands benefit by an hourly premium varying as the above and with the saving in time effected by the workmen on the time allowed.

The formulæ by which the premium due to the men is calculated is given in the table on pages 2552-2553.

### d) *General stores.*

The chargemen and assistant chargemen of the labouring gangs are granted an hourly premium in order to induce them to increase the proportion of time passed on work shown on the lists.

The corresponding formula is given in the table on pages 2552-2553.

## French State Railways.

### a) *Locomotive depots.*

The quarterly management premiums due to the management staff at the depots is increased in proportion to certificate of merit awarded by the depot carrying marks from 0 to 20. These marks are the arithmetical mean of the partial marks obtained under each of the following heads, for which marks are given :

*a*) Failures;
*b*) Maintenance;
*c*) Cost per kilometre;
*d*) Fuel consumed per tonne-kilometre;
*e*) Oil consumed per kilometre;
*f*) Time lost.

The premium is augmented if the marks awarded exceed 12; it is reduced when they are less than 12. The legal premium is awarded when the marks equal 12.

The charge hands receive monthly premiums calculated by the formula : $P = n \times K \times 20$ fr., in which $n$ represents the number of days on duty and K a percentage depending upon the output of the gang supervised.

### b) *Main workshops.*

The management staff, the head of the main works, and the foremen benefit by a legal premium the increase depending upon the general output of the shop and the reduction in the general charges. In addition, the premium can be reduced if mistakes are made or in the event of any undesirable practice taking place.

The chargemen and assistant-chargemen are only concerned in the normal monthly production of the gang they control.

The formulæ by which the premiums are calculated are shown in the table on pages 2552-2553.

### French Nord Railway.

#### *Locomotive depots.*

The increase in the legal premium due to the superintendents and assistant superintendents of the depots, the controllers and the leading drivers consists in a percentage of the average premium of the drivers in service of the depot for the quarter under consideration, with a reduction in ratio to the number of failures or casualties; this percentage is given by the formula :

$$\frac{P}{1\,400}\left(1-\frac{3i}{20}\right)$$

in which P = the average premium of the drivers at the depot, $i$ = number of failures per 100 000 km.

The foremen and chargemen controlling repair gangs profit by a premium consisting ot two parts :

*a*) the average of the premiums allocated to assistant-chargemen (see chapter III, section 3);

*b*) a fixed premium for each engine repaired during the quarter (deductions being made for any failures occurring during the period of guarantee).

### Paris, Lyons & Mediterranean Company.

#### a) *Locomotive depots.*

The quarterly premium allotted to the management staff of the depot is equal to the standard legal premium to which is added a personal increase and an increase for the depot.

The personal increase is based upon a note granted each employee according to the work done.

The increase for the depot is calculated by a formula which is given in the table on pages 2554-2555 which takes into account the following factors :

The mean daily mileage of the engines;
The mean daily mileage of the drivers;
The mean daily mileage of the firemen;
The daily work done by the drivers and firemen;
The output of the workmen;
The number of failures.

The foremen are only affected by the first and the last two of these factors.

The chargemen and assistant-chargemen are only affected by the output of the men they control.

#### b) *Main workshops and repair shops.*

A note is awarded to each member of the management staff; a scale fixes for each grade the total amount of the premium in relation to this note.

In future, the premiums of these agents will take into account the results obtained in reducing the general charges of the shop and also, if possible, saving materials.

The chargemen and under-chargemen will be given a premium based upon the output of the men under their charge.

### Paris-Orleans Railway.

#### a) *Locomotive depots.*

The increase in the legal quarterly premium granted to the superintendents, assistant superintendents, and foremen at the locomotive depots, to the inspectors and leading drivers, takes into account the following factors :

Consumption of fuel;
Cost of repairs;
Number of failures;
Cost of office staff;
Result of special working.

The chargemen and assistant-chargemen are affected only by certain of these factors according to the work they do. The total of the premiums paid to the chargemen and assistant-chargemen at the works is added together and divided among the men who are concerned, taking into account the work done by each.

### b) *Maintenance.*

The increase in the quarterly premium allotted to the inspectors, heads of repair gangs and foremen is the result of the following factors :

Output of the workmen engaged on repairs carried out on repair sidings;
The cost of repair materials on repair sidings;
Number of engines lifted (converting into a lift, part lift, inspection of axle boxes, etc.);
Number of brake inspections;
Economies effected by using second hand material;
Number of failures attributable to maintenance.

The premium allocated to the chargemen and assistant-chargemen depends upon the same factors : the total amount granted to each man is determined in the same way as for the chargemen and assistant-chargemen in the locomotive depots.

### c) *Main locomotive workshops.*

The management staff in the main shops from the assistant-foreman up to the heads of the shops are granted increases of the management premiums based upon the results obtained under the following heads :

Time taken to repair the locomotives;
Time spent on repairs;
Time detail parts take in the shops;
Reduction in general charges.

The chargemen and assistant-chargemen are granted a premium based upon the same factors.

The total of the augmented premiums paid to all the management staff in any one works is brought together and divided according to the work done by each.

### d) *General stores.*

The charge hands of the labouring gangs receive a premium based upon the results obtained under each of the following heads :

Cost per ton handled;
Time wagons are kept out of traffic;
Delay in despatching materials to the works.

The premiums are brought together for each stores and distributed among those concerned, according to the work done per man.

⁂

The formula by which the amount of premium due to the management staff at the depots, main repair shops, and general stores are calculated are shown in the table of pages 2556-2559.

## Other railways.

### Home Railways.

### *Société des Transports en Commun de la Région Parisienne (S. T. C. R. P.)*

The chargemen and assistant-chargemen receive an hourly premieum, the value of which is proportional to a certificate of merit having marks from 0 to 20.

*Indre Tramways.*

1. The superintendent of the depot responsible for the maintenance of the stock, and for supervising the engines receive each month a premium equal to 20 % of the fuel and oil saved by the drivers.

2. The trafic inspectors are given a premium of 5 fr. for every 1 000 fr. of receipts obtained above a fixed minimum.

**Jura and Haute-Saône Light Railways.**

The leading drivers and depot superintendents are given premiums calculated upon the average saving of coal and oil or current shown for each locomotive.

### Colonial railways.

**Lower Congo to the Katanga Railway.**

The heads of the workshops, foremen, and charge hands are given a monthly premium calculated on the Rowan system.

The staff at the sheds are given premiums calculated upon the kilometres run by the locomotives and the fuel saved.

## SECTION No. 3.

## Premiums and gratuities granted to Headquarters Staff, Departmental Headquarters, Divisional Headquarters, or District Offices carrying out office work.

**French Est Railway.**

— Central Office dealing with the wages of the operating staff.

— Employees in divisional offices preparing permits for the train staff.

Premiums in proportion to the time saved by improving the output.

If A is the time allowed in hours to a group to carry out a certain work,

and T the time actually taken by the group, the gratuity G allocated (when T is at the most equal to A) is :

$$G = 0.125\ A + K\ (A - T).$$

According to the values of the coefficient of economy

$$e = \frac{A - T}{A}$$

K varies from 1 when $e = 0$ to 2 when $e > 0.4$.

The individual gratuity is calculated in proportion to the time on duty during the work for which the premium is allowed, with an increase of 1/5 for the head of the group.

— Rolling stock and Locomotive Running Department Accountant's Office, using calculating and statistical machines :

Operators on the punching machines : hourly gratuities of 0.15 fr. for 200 cards punched, and 4 fr. for 430 cards.

Operators on the calculating machines for dealing with the wages of the staff : hourly gratuity of 1.05 fr. for 39 accounts prepared in the hour, at 7.75 fr. for 60.

**Paris-Orleans Railway.**

The Head Accountancy Office dealing with the wages of the operating staff, using calculating machines :

For each man and by the month is calculated :

*a*) the number of individual accounts completed, the increase diminishing from

30 to 5 % when the employee has been from 1 to 8 months in the office;

*b*) the time in hours working at the machines;

*c*) the quotient $\frac{a}{b}$.

The individual monthly premium is calculated by multiplying the number of hours employed at each machine by the hourly premium as a function of mean hourly output. This premium rises from nothing for an output of less than 31.5 individual accounts to 1.85 when the hourly output is 49.5.

Locomotive Running Department; office dealing with premium and mileage :

— The female staff used to punch the cards for the sorting machines, and « Powers » tabulating machines

$$P = 2N \times \frac{A - 90N}{A}$$

N = the number of hours spent punching the cards per month.

A = the number of cards punched during the month.

The formula gives :

For an average of 95 cards per hour a premium each month of 17.35 fr.;
For an average of 100 cards per hour a premium each month of 33 fr.;
For an average of 105 cards per hour a premium each month of 47 fr.

## Control common to all the main French Railways.

### 1. *Checking the rates for goods sent by slow goods train.*

*a*) The checkers are allocated : 0.05 fr. for each rate corrected and 1 fr. for each hour saved.

The formula on which gratuities are awarded is as follows :

$$G = 0.05R + 1.00\left(\frac{E + 2.5R}{25} - H\right)$$

in which :

R = the number of rates corrected;
E = the number of despatches checked;
H = the time taken.

Penalties are imposed for errors and omissions due to the checkers and inspectors.

*b*) For the staff working the calculating machines the following formulæ are applied :

Hand machines :

$$G = 1.00\left(\frac{E + 2.5R}{125} - H\right)$$

Electric machines :

$$G = 1.00\left(\frac{E + 2.5R}{166} - H\right)$$

in which :

E = the number of consignments;
R = the number of rates;
H = the number of hours of work.

*c*) For the staff preparing advice notes of corrected rates :

$$G = 1.00\left(\frac{N}{10} - H\right)$$

in which :

N = the number of advices prepared;
H = the number of hours of work.

*d*) For the checkers :

$$G = 0.20E + 0.50\left(\frac{V}{12} - H\right)$$

in which :

E = the number of mistakes found;
V = the number of articles rechecked;
H = the number of hours work.

## Table showing the formulae used by certain railway
## in var

| | |
|---|---|
| **Belgian Nat** | |
| *a*) **Locom** | |
| Savings made by the whole of the locomotives in the shed<br>$P_1 =$ | |
| a/100 of the price of the standard coal per ton of combustible. | $+ b$ fr. par 100 kgr. of oil. |
| *a*) and *b*) vary with the position occupied :<br>$\left.\begin{array}{l} a = 1 \\ b = 0.75 \end{array}\right\}$ for all officials other than instructor drivers. | |
| *b*) **Main w** | |
| Time taken for repairs. | |
| $\frac{d}{D} = \frac{\text{average time taken for the most recent repairs in the shop considered}}{\text{average time taken for the most recent repairs in the workshops of equal importance}}$<br>(In order that a premium may be allotted : $\frac{d}{D}$ must be $> 0.7$). | |
| **Staff responsible for superv** | |
| Average daily output in 1926. | Av |
| $R_1 = \frac{N_1}{T_1} \times 8$. For the meaning of $N_1$ and $T_1$ see above. | $R_2 = \frac{N_2}{T_2}$ |

## culate the premiums awarded to the management staff ps

way Company.

ts.

| iums for keeping in good order the engines booked to the drivers of the shed $P_2 =$ | | Total $P = P_1 + P_2$ |
|---|---|---|
| of the premiums for good mainten- of their engines granted to the e of the drivers. | $+ \frac{50}{384}$ of the premiums for keeping the engines in good order granted to those drivers who have exceeded since last general repairs the mileage required. | ... |

s.

| ber of wagons — 10 hours repaired. | Number of hours of work. | Total. |
|---|---|---|
| $= \frac{\text{Number of wagons — 10 hours repaired during the month.}}{\text{Average number of wagons — 10 hours repaired in 1926.}}$ | $\frac{T_1}{T_2} = \frac{\text{Monthly average number of hours in 1926}}{\text{Number of hours of work in the month considered.}}$ | $P = P_1 \times \frac{d}{D} \times \left(\frac{N_2}{N_1}\right)^2 \times \left(\frac{T_1}{T_2}\right)^3$<br>$P_1$ is fixed per wagon — 10 hours according to the size of the shop. |

**organisation of the workshops.**

| output in the month considered. | Total. |
|---|---|
| the meaning of $N_2$ and $T_2$ see above. | $P = 100 [1 + 3 (R_2 - R_1)] 3.$ |

## Fren

*a*) **Locomotives Depots.**

| Improvement on ordinary booked working. | Use of enginemen. | Output of the shop. |
|---|---|---|
| $N^1 = \frac{\text{Premium train mileage}}{\text{Total train mileage}}$.<br>The mileage of engine is subject to a premium when it exceeds a certain minimum and when the engine has been handled by more than 4 different sets of men.<br>Increase :<br>$N'^1\ \%  = 0.66\ (N_1 - 60)$<br>(if $N_1 > 60\ \%$).<br>Reduction :<br>$N'^1\ \% = 0.66\ (50 - N_1)$<br>(if $N_1 < 50\ \%$).<br>Neither reduction nor increase :<br>if : $50\ \% < N_1 < 60\ \%$. | $N_2 = \frac{\text{Number of enginemen days used in driving the engines}}{\text{corresponding allocation.}}$<br>The allocation results from the days in service and from the kilometres run in supplementary workings.<br>Increase :<br>$N'_2\ \% = 3\ (106 - N_2)$<br>(if $N_2 < 106\ \%$).<br>Reduction :<br>$N'_2\ \% = 3\ (N_2 - 110)$<br>(if $N_2 > 110\ \%$).<br>Neither increase nor reduction<br>if : $106\ \% < N_2 < 110\ \%$. | $N_3 = \frac{Rr + Pp - N}{Rr + Pp}$<br>R = number of theoretical km.<br>*paired* by the shop (coeffici<br>taken into account the degree<br>complication of the engines).<br>P = number of theoretical km. c<br>*ried out* by the depot.<br>*r* = the hourly allocation per theoret<br>km. repaired.<br>*p* = the hourly allocation per theoret<br>km. run.<br>N = number of man-hours at the wo<br>shops during the period con<br>dered.<br>$N'_3 = 1.25\ \frac{N_3 + 0.20}{2}$. |

The reduction of the premium for untoward incidents is calculated as follows: «ΣTC >

*b*) **Repair shops and posts.**

|  |  |
|---|---|
| $R = \frac{K\Sigma A - (\Sigma E + \Sigma M)}{K\Sigma A}$ | K = local coefficient.<br>ΣA = total time allotted for the wagon repair.<br>ΣE = total time corresponding to the execution.<br>ΣM = total unrated time taken during the month. |

## Railway.

| Use of labourers. | Materials. | Total. |
|---|---|---|
| $= \frac{\text{Number of man-days used in the shed.}}{\text{the corresponding allocation.}}$<br>ase :<br>$N'_4\ {}^{\circ}/_{\circ} = 1.5\ (106\ {}^{\circ}/_{\circ} - N_4)$<br>$(\text{if } N_4 < 106\ {}^{\circ}/_{\circ})$.<br>eace :<br>$N'_4\ {}^{\circ}/_{\circ} = 1.5\ (N_4 - 110\ {}^{\circ}/_{\circ})$<br>$(\text{if } N_4 > 110\ {}^{\circ}/_{\circ})$.<br>er increase nor decrease if :<br>$106\ {}^{\circ}/_{\circ} < N_4 < 110\ {}^{\circ}/_{\circ}$. | $N_5 = \frac{\alpha - D}{\alpha}$ $\alpha$ = allocation. D = issues.<br>Certain materials are not taken into account owing to their nature (smoke tubes, springs, etc...) or of the use made of them (materials for apprentices, materials for first construction, etc...)<br>$\alpha$ (sum of money) = $A + BPm + CRm$.<br>A = constant for a depot.<br>B = allocation for 1 000 theoretical km. run.<br>C = allocation for 1 000 km. repaired.<br>$Pm$ = theoretical km. run.<br>$Rm$ = Theoretical km. repaired.<br>(The theoretical km. are deduced from the actual km. by taking into account shunting in stations, types of engines, special difficulties of working, and the age of the engines.)<br>Increase :<br>$N'_5\ {}^{\circ}/_{\circ} = 2.5\ \ N_5 \text{ if } N_5 > 0$<br>Decrease :<br>$N'_5\ {}^{\circ}/_{\circ} = 2.5\ (N_5 - 10)$<br>$\text{if } N_5 < -0.10$<br>Neither increase nor decrease if :<br>$-0.10 < N_5 < 0$. | $P = P^s\ (\alpha N'_1 + \beta N'_2 + \gamma N'_3 + \delta N'_4 + \epsilon N'_5)$ $\alpha\ \beta\ \gamma\ \delta\ \epsilon$ vary with the position held.<br>$P_s$ = legal standard premium.<br>If necessary, to this are added supplementary allocations so that for the whole of the system :<br>$N'^1 + N'_2 + N'_3 + N'_4 \geqslant 0.85$<br>and $N'_5 \geqslant 0.45$. |

number on incidents by class.
coefficient (per incident).
coefficient of reduction (per depot).
coefficient varying with the grade.

| | |
|---|---|
| Repair managers and assistant managers, foremen. | $P = P_s\ (1 + gR)$.<br>$g$ = coefficient varying according to grade.<br>$P_s$ = standard legal premium. |

Chargehands and assistant chargehands :
$P = K \times 125\,R$ (monthly premium).
K = coefficient varying according to grade.

French

*c)* **Main Workshops.**

| Works managers, foremen. |
|---|
| $P = P_s\left(1 + K - \frac{T_0}{T}\right)$<br>$P_s$ = Quarterly legal premium.<br>K = basic coefficient (according to the shop.)<br>T = total working time in the section controlled.<br>$T_0$ = time taken in this section on work not shown on the lists. |

*d)* **Main Stores.**

Hourly premium of the chargehands and assistant chargehands of the labouring gang

$$g = p\frac{a \times E + M}{E + M}$$

**Main Workshops.**

| Output. | Reduction of general charges. |
|---|---|
| $\frac{N - n}{N}$<br>$n$ = normal production.<br>N = actual production. | $R - \frac{Dfg}{M_0}$<br>$Dfg$ = expenditure on general charges of the shop during the quarter dered.<br>$M_0$ = the total cost of useful labour during the same period.<br>R = the value of $\frac{Dfg}{M_0}$ considered as normal. |

## ilway (*continued*).

Chargemen and assistant chargemen.

$P = P_1 \left[ K + \left( \frac{g}{t_a} - m \right) \frac{T - T_o}{T} \right]$ hourly premium.

$K$ = 1.4 for chargehands.

1.07 for assistant chargemen.

$P_1$ = Augmented hourly premium of the workmen in the section considered. (see chapter III, section nº 3).

$g$ = time made up by the gang on the total allowed $t_a$.

$m$ = coefficient varying for each gang.

$T$ = total working time of the gang.

$T_o$ = time taken by the gang on work not shown on the lists.

E = total time taken to carry out work shown on the lists for the whole of the stores.

M = total time taken for carrying out work not shown on the lists.

$p$ = average premium allotted to the labourers in relation to their output. (see chapter III, section 4).

$a = 2$ for the chargehands
and 1.5 for the assistant chargehands.

## ilways.

| Bad work, errors. | Total. |
|---|---|
| = reduction factor in francs as punishment for bad work or mistakes. | Management Staff :<br>$p = 2\,P_s \left[ \frac{N - n}{N} + \left( R - \frac{Dfg}{M_o} \right) \right] - K.$<br>$p$ = extra premium added to the quarterly management premium.<br>$P_s$ = legal quarterly premium. |

Increase in premium for the depot.

**Management staff :**

$$N = \frac{2\,(p_1 + p_2 + p_3) + 3t + 6l + 5d}{20}$$

$p_1\,p_2\,p_3$ $t$ $l$ and $d$ are notes bearing from 0 to 20 corresponding to the results obta

| Average daily mileage run by the engines $P_1$ compared with a standard mileage $P'_1$ fixed quarterly. | Average daily mileage of the drivers $P_2$ compared with a standard mileage $P'_2$ fixed quarterly. | Average daily mileage of the firemen $P_3$ compared with a standard mileage $P'_3$ fixed quarterly. | Average daily output in t<br>of the drivers and firemen<br>$T = \frac{\text{Total hours of duty d by the drivers and men.}}{\text{Total number of day duty of the drivers firemen compared normal value T 6 3/4 hours for all depots.}}$ |
|---|---|---|---|
| $\frac{P_1 - P'_1}{P_1}$ is calculated. | $\frac{P_2 - P'_2}{P_2}$ is calculated. | $\frac{P_3 - P'_3}{P_3}$ is calculated. | $\frac{T - T'}{T}$ is calculated. |

| | | Personal increase. | Total. |
|---|---|---|---|
| Foremen.<br>The increase in premium of the depot is based, as regards the men, on :<br>$N_1 = \frac{p_1 + 2l + 2d}{5}$<br>n each of the following subjects : | | The personal increase is based upon a note given to each employee according to the work done. | Premium = average premium<br>+ personal increase<br>+ depot increase. |
| utput of the workmen measured by the theoretical number of lifts carried out in the month.<br>his number is compared to a standard value<br>$L' = \left(e - \frac{cn}{1.27}\right) 0\ 21$<br>= average number of fitters used in the depot.<br>= the number of fitters required.<br>= coefficient. | Number of failures D compared to a normal value D′ representing a number of failures which must not be exceeded, equal to 2 per 100 000 km. | | |
| $\frac{L - L'}{L}$<br>is calculated. | $\frac{D - D'}{D}$<br>is calculated. | | |

## Paris-Orlea

**Locomotive depots.**

| Consumption of fuel. | Cost of repairs. | Number of untoward incidents. |
|---|---|---|
| $A = \frac{C - c}{C} \times 100$ | $B = \frac{R - r}{R} \times 100$ | $C = \frac{LK - B}{LK} \times 100$ |
| C = amount of fuel allotted to the depot (in terms of km. run).<br>$c$ = actual consumption. | R = price allotted for repairs to the locomotives in terms of the number of km. (material and labour).<br>$r$ = actual expenditure. | K = number of incidents allowed p 100 000 km. run.<br>L = mileage worked by the depot 1 000 km.<br>B = number of incidents (counted simple, double or triple accor ing to importance). |

**Maintenance.**

| Rolling stock repairs. | | | |
|---|---|---|---|
| Output of men carrying out repairs in sidings. | Average quantity of material used per repair in the sidings. | Number of lifts. | Number of brake overhauls. |
| $A = \frac{N_1 - N}{N} \times 100$ | $B = \frac{M_1 - M}{M} \times 100$ | $C = \frac{L_1 - L}{L} \times 100$ | $D = \frac{R_1 - R}{R} \times 100$ |
| $N_1$ = average number of repairs carried out per day of 8 hours.<br>N = allocation. | $M_1$ = average consumption per vehicle.<br>M = allocation. | $L_1$ = average number of theoretical units (in terms of the complication of the vehicles) per day of 8 hours.<br>L = allocation. | $R_1$ = average number imaginary brake ac justments (taking int account the extent c work done) per da of 8 hours.<br>R = allocation |

## ilway.

| Cost of works staff. | Output of special working. | Total. |
|---|---|---|
| $v = \frac{LH - h}{LH} \times 100$<br>$= \frac{6v + 4v'}{10}$<br>$v' = \frac{t - 2.0}{2.0} \times 100$ | A special order fixes E from the actual number of men used for special working in comparison with the allocation per 1 000 km. of special workings. | Superintendents, district superintendents, foremen, inspectors, leading drivers :<br>$P = (1 + K) P_s$ $P_s$ = legal quarterly premium.<br>$K = aA + bB + cC + dD + eE$<br>$a$, $b$, $c$, $d$, $e$ are coefficients varying with the grade and duties of the employees considered (for the leading drivers the last two elements D and E are not taken into account).<br>For the chargehands and assistant chargehands, of labouring gangs (cleaners) :<br>$P = 40 + 4 \frac{H - h}{H} \times 100$ $H$ = number of men allowed. $h$ = actual number of men allowed.<br>For the chargemen and assistant chargemen of gangs of skilled workmen :<br>$P = 5A + 2B$<br>The chargehands and assistant chargehands of the coal gang men :<br>$P = 5v'$ |
| = allocation per 1 000 km. in hours of works staff.<br>= number of actual hours.<br>= theoretical hourly output in handling fuel (compared in the formula to the average output : 2 T.). | | |

| | Incidents. | Total. | |
|---|---|---|---|
| nomies resulting from the use of old materials. | Number of incidents that can be charged to repairs. | Inspectors,<br>Repair managers,<br>Foremen. | Chargemen and assistant chargemen. |
| $E = \frac{V_1 - V}{V} \times 100$ | $F = \frac{I_1 - I}{I} \times 100$ | | |
| = average saving effected by using old materials per vehicle.<br>= allocation. | $I_1$ = number of incidents recorded.<br>I = allocation. | $P = (1 + K) P_s$<br>$K = 0.3\ A + 0.15\ B + 0.15\ C + 0.10\ D + 0.05\ E + 0.25\ F.$ | $P = K \times 9$ |

**Locomotive shops.**

### REPAIRS TO LOCOMOTIVES.

| Time in the works. | Time taken for the repair. | Time detail parts are in the sh |
|---|---|---|
| $A = \frac{N - n}{N} \times 100$ | $B = \frac{H - h}{H} \times 100$ | $C = \frac{T - t}{T} \times 100$ |
| N = number of days allowed for the locomotives repaired (time varying with the extent of repair)<br>$n$ = number of days taken. | H = number of working hours allotted for the repairs of the engines (varies according to the repairs done).<br>$h$ = number of hours taken. | T = number of days allowed f pairs of parts sent to the s<br>$t$ = number of days taken. |

**General stores.**

| Cost per ton handled. | Time wagons are held out of traffic. |
|---|---|
| $A = \frac{H - h}{H}$ | $B = \frac{G - g}{G}$ |
| H = average cost per ton.<br>$h$ = allotted cost per ton. | G = average normal time stopped.<br>$g$ = actual time. |

## Railway (*continued*).

| General charges. — Workshop expenses. | Total. | |
|---|---|---|
| General charges and workshop expenses. | Shop managers, first foremen and foremen. | Chargehands and assistant chargehands. |
| $D = \frac{F - f}{F} \times 100$ | $P = P_s\,(1 + K)$<br>$K = 0.5\,A + B + 0.5\,C + D$ | $P = \frac{230 \times K}{0.50}$ |
| = total of the general charges allocated in terms of the number of men.<br>= actual expenditure. | | |

| Delays in dispatching materials to the works. | TOTAL. |
|---|---|
| $C = \frac{R - r}{R}$ | $P = \frac{100 \times K}{0.5}$<br>$K = 0.5\,A + B + 0.5\,C$ |
| = time allowed for sending materials out.<br>= time taken for sending out materials. | |

Penalties are imposed for mistakes not discovered as well as for mistakes committed.

The average premiums paid monthly amount to 45 fr. approximately for each man. It represents about 4 to 5 % of the rate of pay.

For the clerks in charge of a section or assistant chief clerks, the premium is multiplied by the coefficients 1.2 and 1.3 the average obtained by dividing by the total number of men under their orders the total of the premiums gained by these latter.

### 2. *Checking the rates for goods sent by fast train.*

As from the 1 January 1923, a premium of 0.25 has been given for each rate drawn up above the 185 required monthly.

In addition, a premium equal to 0.25 % of the products of the rates quoted is granted for the part of this product which exceeds 5 500 fr. in a month. Every error results in a penalty of 0.50 fr. per mistake, and 0.50 % of the total of the incorrect rate.

The average premium paid monthly amounts to about 45 fr. per man; this represents approximately 4 to 5 % of the total wage.

### 3. *Statistical machines.*

*a*) Shop in which the cards are perforated :

The formula in use by which the gratuities are arrived at is as follows :

$$G = H. N. (Q - r)$$

in which :

H = the number of hours of work;
N = the hourly premium varying with the output;
Q = a coefficient of quality (exactitude in dealing with the numbers of stations);
$r$ = a reduction factor corresponding to the mistakes committed other than those in connection with the numbers of stations.

The average is about 120 fr. representing about 12 % of the pay.

*b*) Card sorting shop :

— Sorting the cards :

$$G = 2 \text{ fr.} \left(\frac{E}{1\ 250} - H\right)$$

— Rearrangement of the cards, space and total :

$$G = 1 \text{ fr.} \left(\frac{E}{2\ 500} - H\right)$$

— Search for incorrect cards :

$$G = 1 \text{ fr.} \left(\frac{N}{40} - H\right)$$

in which :

E = number of consignments per month;
N = number of incorrect cards;
H = number of hours the machines are used.

The distribution of the gratuity is made as a whole, because the speeds of the machines are not the same, and because the head of the office must be left full innitiative with regard to giving out the various work to those men likely to give the best output.

The chief of the sorting shop (head clerk) is counted as 1.5 and each of the others as 1 unit (or fraction if he has been away during the month).

The premium represents about 11 % of their pay.

*c*) Tabulating shops (printing by the Hollerith tabulating machines from the perforated cards).

The formula for the individual gratuity is :

$$G = 0.125\,H + \frac{E - bH}{800}$$

in which :

$E =$ the number of cards tabulated;
$H =$ the number of hours taken to tabulate the cards;
$b =$ the basic output (varying from 2 200 to 2 800 according to the kind of work needed).

No premium is alloted unless

$$E - b\,H > 0.$$

When two machines are used at the same time the employee receives during the time the two machines are working, the mean of the gratuities obtained from the use of both one and the other machines.

Premium of 140 fr. on the average, which represents about 13 % of the pay.

### 4. *Recapitulation of the accounts for incoming goods by means of the Mercédès machines.*

A premium of 1.50 fr. per hour is allotted, the formula being

$$1 \text{ fr. } 50\left(\frac{N}{60} - H\right)$$

in which :

$N =$ the number of lines copied;
$H =$ the number of hours of work.

Average of 95 fr., a sum which represents about 9 % of the pay.

### 5. *Checking the inwards traffic.*

This consists in checking by hand the advice notes of incoming traffic from the stations with the tabulated lists.

The gratuity is calculated by the following formula :

$$G = 0.175\,H + 0.30\,\frac{(130 + 20)\,E}{700} - H$$

in which :

$E =$ the number of mistakes found;
$H =$ the number of hours of work with the condition :

$$\frac{150\,E}{700} - H > 0.$$

The average about 60 fr. representing approximately 6 to 7 % of the pay.

### 6. *Checking the numbers from the dispatching stations, shown on the tabulated list.*

By means of a Burroughs machine the numbers from the stations are added together.

The formula for the premium is :

$$G = 0.125\,H + 0.625\,\frac{N + 20\,E}{1\,000} - H$$

in which :

$E =$ the number of mistakes found;
$N =$ the number of articles checked;
$H =$ the number of hours of work, with the condition :

$$\frac{N + 20\,E}{1\,000} - H > 0.$$

Average premium about 25 fr. representing about 3 % of the pay.

### 7. *Accounts classifying work.*

For classifying consignment notes by fast goods trains and advice notes of collection of charges which, in view of the checking that has to be done by the Common Control, ought to be grouped by the despatching stations after having been checked by the receiving stations output premiums based upon the saving of time made by each man, have been instituted quite recently.

The formula used is of the type :

$$G = 1 \text{ fr. } (A - T)$$

in which :

$A$ = the time allowed;
$T$ = the time taken.

$A$ has been fixed by taking into account the average output required for the different classes of papers to be sorted :

For despatch notes :

$$A = \frac{N}{275}$$

For receipt of payment, fast goods traffic :

$$A = \frac{N}{190}$$

For receipt of payment, slow goods traffic :

$$A = \frac{N}{225}$$

$N$ being the number of documents classified.

*Société des Transports en Commun de la Région parisienne.*

1. Typewriting work :

Monthly premium :

$$P = t\left(\frac{LH}{H h}\right) - Ha$$

$t$ is the rate allowed,
$L$ is the number of lines type written,
$H$ is the time the employee is on duty,
$h$ the time taken for various works such as : collecting papers; putting in holders, taking short hand notes, etc.
$a$ the minimum hourly task imposed.

2. Indexing papers, sorting papers and office work in general :

Individual monthly premium :

$$P = \frac{V - (t \times h)}{2}$$

in which :

$V$ represents the value of the work done by the employee during the month, calculated as follows :
— number of simple individual operations multiplied by the time allowed for each, the whole of which being valued at the rate of $t$ fr. per hour.
$h$ is the number of hours actually on duty during the month.
$t$ is the allowed rate per hour.
2. represents the proportion of the saving allotted to the staff (50 %).

# CHAPTER II.

## PREMIUMS AND GRATUITIES AFFECTING THE EMPLOYEES IN THE OPERATING DEPARTMENT.

### SECTION No. 1.

### Premiums and gratuities granted to employees dealing with passengers in the trains or in the stations on arrival, or on departure.

Most of the Companies grant to the staff dealing with passengers a premium which is usually a function of the number of passengers with incorrect tickets, and of the sum of money collected as supplement.

The table below, indicates the rates in force :

| — | | Premium fixed for each passenger whose ticket is out of order. | Percentage of the sums collected, granted as supplement. |
|---|---|---|---|
| Belgian National Railway Company | | 0.10 | 1 % |
| French Main Railways | | 0.15 | 2 % |
| Algerian State Railways | | 0.15 | 2 % |
| Conakry to the Niger Railway | | 0.10 | 1.50 % |
| Thiès to the Niger Railway | | 0.10 | 1.50 % |
| Tunisian Railway Company | | 0.15 | 3.75 % |
| Northern Light Railways | Collectors | ... | 1 % |
| | Drivers | ... | 0.50 % |
| Deux-Sèvres Departmental Tramways | | ... | 1 % |
| Landes Railways | | ... | 5 % |
| Sfax to Gafsa Railway | | ... | 3 % |
| French Dahomey Railway Company | | ... | 1 % |

There are various methods of distributing the premiums between the man who discovered the passenger with incorrect tickets and the inspector who collected the excess fare.

The premiums are generally paid on the same basis as when in the event of fraud, a summons has been served on a traveller without any excess fare having been collected.

In addition, certain Companies, such as the Est and the Paris, Lyons & Mediterranean allow to the travelling inspectors a monthly gratuity based upon the number of irregularities discovered during their tours of inspection.

## SECTION No. 2.

### Premiums and gratuities granted to the staff dealing with checking and handling of goods.

A certain number of the great Companies grant special gratuities to the agents who discover and report false statements of weight or of the nature of goods in order to encourage them in their work.

*False declarations of weight.*

**Belgian National Railway Company.**

The gratuity is proportional to the importance of the sums recovered :

15 % when the amount is up to 3 000 fr.;
10 % between 3 001 and 6 000 fr.;
5 % between 6 001 and 10 000 fr.;
2 % between 10 000 and 50 000 fr.;
1 1/2 % on the part exceeding 50 000 fr.

(based upon the relative supplementary rates for the Belgian part of the journey.)

If the checking of the irregularities involves weighing, half the gratuity is granted to the employee who discovers the irregularity, the other half being distributed between the men who carried out the weighing.

If not necessary to weigh the consignment, the reward goes without deduction to the men who found out the error.

**Main French Railways.**
**Midi.**

Men in the lower grades (grades 1 to 7) :

25 % of the amount received up to 20 fr.;

Above 20 fr. : 25 % for the first 20 fr. and 5 % for the remainder.

(With a maximum of 100 fr. per consignment.)

**Paris-Orleans.**

31.25 % of the sum collected up to 20 fr. of surtax.

6.25 % for the part above 20 fr.

(With a minimum correction of rate of 2 fr.)

**Nord.**

Special gratuities without fixed formula calculated by taking into account :

— the grade, the degree of specialisation, the initiative, and the persistance of the man who found the irregularity, as well as the total of the supplementary charge.

**Paris, Lyons and Mediterranean.**

15 % of the additional payment collected up to 1 000 fr. inclusive;

10 % of the additional payment collected from 1 000 to 2 000 fr.;

5 % of the additional payment collected from 2 000 to 4 000 fr.;

2 % of the additional payment collected from 4 000 to 10 000 fr.;

1 % above 10 000 fr.

### *False declarations as to the class of goods.*

#### **Belgian National Railway Company.**

The same formula as for checking the weight is applied, a formula which also shows in cases of false declarations, relative to the dimensions at the despatching point, or at the destination of the goods.

#### **Main French Companies.**

#### **Midi.**

The same formula as for checking the weight is applied, men in the medium grades being also granted a share.

A special gang has been formed to supervise the conditions under which the despatches of cattle are carried out, and to draw up the rate when mistakes or frauds, regarding the destination of the cattle, the indication of their number or of the floor area of the wagon, are found. The gratuity is proportional to the importance of the amount of money recovered :

5 % for monthly corrections not exceeding 500 fr.;

3 % for monthly corrections of from 500 to 1 000 fr.;

1 % above 1 000 fr.

(With a maximum of 20 fr. per consignment.)

#### **Paris-Orleans.**

— 10 % of the additional charge with minimum of 2.50 fr. and maximum of 75 fr. for goods not packed.

— 20 % of the additional charge with a minimum of 5 fr. and a maximum of 125 fr. for packed goods.

#### **Nord.**

#### **Paris, Lyons and Mediterranean.**

Same formulæ as for weight checks.

In addition to the premium mentioned above, and more particularly reserved to the checkers, the porters properly speaking, are granted on some of the Companies

### *Gratuities based upon the tonnage handled.*

#### **Main French Railways.**

In certain yards of the large stations, such as Bordeaux-Saint-Jean, Agen and Cette, the company grants a monthly premium of 0.75 fr. per ton handled by a gang during the month considered above a minimum tonnage. The premium is divided up among the men, forming the gang, according to the number of days of work done by each.

For men in the management and certain special staff, the premium is fixed as follows :

| | | | |
|---|---|---|---|
| Leading hands | 37.50 | per ton of increase above the average output. | of the gang. |
| Charge hands | 150.00 | | of the yard. |
| Assistant charge hands | 125.00 | | |
| Under charge hands | 100.00 | | |
| Labourer | 37.50 | | |

Money is withheld both for the management and for the other staff benefitting, when mistakes have diminished the quality of the work.

**Est Railway.**

A special system of gratuities has been instituted for the tranship sheds near the main shunting stations (see section 3 below).

The actual work done in the shed being carried out by a contractor, the special premium for tranship work is only applied to the supervisory staff.

Each time that during any one period of 24 hours the time allotted for carrying out the transhipping work compared to the time during which the contractor has worked reaches or exceeds the mean value obtained before the premium system was applied, the whole of the men supervising the transhipment work are granted a collective premium which increases as the amount of the fixed quantity of work is further exceeded.

The time allocated for the transhipment is determined by taking into account the number of tons transhipped, and the kind of material transhipped.

The base rate of the premium in terms of output obtained is the same as the rate adopted for the fixed premium in the other sections of the marshalling yard.

The collective premium, the parts of the individual premium, the awards and penalties, are calculated as in other parts of the yard (see section 3 below).

## SECTION No. 3.

## Premiums and gratuities granted to other employees in the operating department.

Independently of the men dealing with the inspection of passenger traffic on the one hand, and on the other of the operations of sorting and handling goods, men in the operating department can benefit in certain companies by special premiums and gratuities intended to interest the staff in the working of the shunting yards, the fast and ordinary goods traffic offices, recovering of material, savings in expenditure, etc.

### *Shunters including those stopping wagons by means of brake slippers, and men in the train offices.*

**Belgian National Railway Company.**

*Premiums* are granted to the staff in large railway stations who, by quicker and more intelligent work, facilitate the formation of goods trains.

In each station affected, an account is drawn up of the number of wagons actually shunted. When the number fixed beforehand is exceeded, a premium of 1 fr. is allotted. The weekly total premium is distributed prorata to the number of days of work without distinction of grade, after any penalties have been deducted. The men who benefit from these premiums are : the assistant station masters, the men in the train offices, the shunters, including the pointsmen, the drivers and firemen of the shunting engines, the leading and ordinary examiners.

The average annual amount per man, is about 175 fr. with a maximum per day of 1 fr. The penalties are both collective and individual.

In places of average importance, which do not benefit by premiums for activity, premiums for the good and prompt use of rolling stock have been instituted, in order to stimulate the zeal of the men who can by their method of working, hasten the turn round of the wagons, and thereby increase the use made of them.

The sums paid vary according to the grade, and the number of days of duty.

In addition, *premiums for regularity* are granted to men at the stations and halts, who are directly concerned with the handling of the trains. These premiums are paid quarterly, and vary according to the grade of the man, and the time of actual work and the importance of the station, taking into account any great rushes of work. Money is held back either collectively or individuallly in cases of bad service (trains sent away late, or held beyond the allowed time), failure to observe the regulations as regards safety, etc.

The stations being divided into 6 classes according to their importance, the annual premium varies from about 600 fr. to about 100 fr. for the station master, and from 100 fr. to about 35 fr. for a labourer.

### Main French Companies.

### Alsace-Lorraine.

To prevent the reoccurrence of the number of cases of damage due to shunting accidents, premiums on output have been instituted in all stations where there is continuous shunting by special shunting engines.

These premiums also tend to increase the output of shunting, and to reduce the delays to trains. In stations serving a number of branches, they also lead to these branches being given a regular service.

The formula is variable according as it is a question of a shunting station only, a station having a number of branches, or a station of which the principal traffic is carried out on offloading sidings, or under sheds.

The type of formula generally used is the following :

Let us take a station in which the average daily number of wagons over a year shunted is 1 000 for a daily average of 24 men employed in shunting.

Starting from this average of 1 000 wagons, in increasing or decreasing stages determined by the means available for doing this work, a scale has been established which gives the gross daily premium ($Pc$).

After this, still taking into account the class of work done, the collected amounts to be withheld ($Rc$) on the gross premium are calculated.

The individual premium is determined as follows :

$\frac{Pc - Rc}{N}$, N representing the number of men on duty.

The rates of the amounts held back are usually the following :

2.50 for damage to rolling stock or contents;

1.00 for delays in despatching exceeding 10 minutes;

0.50 for stops of more than 5 minutes at advanced signals;

1.50 for delays of over 30 minutes in working the branches.

When the responsibility for these delays etc., can be brought home, the amounts withheld become individual and are made at the end of the month on the total of the premiums to be granted to the men at fault.

The daily premium varies between 0.75,

and 1.4 : the number takers do not benefit thereby.

### Est Railway.

In each of the 6 large marshalling yards of the System, there is a scale of premiums for good work in which the management staff, the station masters, and assistant station masters, the shunting staff, the signalmen, telephone operators, and rolling stock staff take part, that is to say, everyone having a direct influence upon the proper working of the various sections composing the yard.

The average output that a group of sidings or a yard obtains from its shunting engines over a period of 24 hours, having been arrived at prior to drawing up the premiums, every time that this section during a period of 24 hours obtains a higher output than this average, a premium is granted to the whole of the men having worked in the section during the period given, the premium being naturally greater the greater the extra work done.

With this object in view in each of the sections or yards composing the marshalling yard a number of timings are taken with chronometers to determine the standard times corresponding to each of the different operations carried out in the yard, then the standard gross time is alloted to the section for the whole of the operations carried out over a period of 24 hours. The ratio of the total standard time to the actual time the engines are available during the period of 24 hours, determines the efficiency.

The output can be increased by a bonus in order to take into account the additional savings obtained by certain initiatives giving rise to economies : contrarily, a penalty is imposed when the work of a yard is unsatisfactory, the amount being proportional to the time lost.

On the other hand, in each section the theoretical output is calculated.

The collective premium for good output from a section is then determined in the following way :

The output obtained during a period of 24 hours determines the basic rate of the premium. This value is calculated in such a manner as to represent according to the ouput from 5 to 37 % of the daily highest wage that a labourer can receive. This basic rate is multiplied by the number of men of each grade shown on the theoretical establishment, each grade being given a coefficient which increases with the number of the scales. The collective premium is equal to the product. It is then divided between the various men in the section who have been actually at work during the periods considered proportionally to the coefficient of the grade of each of them.

Certain individual professional mistakes result in the individual premium of the men at fault being suppressed (late on duty, failure to carry out an order, carelessness, etc.).

In addition, the brakesmen can receive over and above the premium of the section in which they work, special brake premiums if their work is satisfactory, that is to say if the percentage of the number of wagons damaged is less than the number of wagons reported before the premium was instituted. In this way the percentage of damage determines a coefficient of premium which multiplied by the number of wagons braked, is the premium to be allotted to the man. The men in other grades are paid this premium increased by the coefficient belonging to their grade.

On the other hand when the number of wagon damages, or in which the load is displaced, is higher than the average value expected, each man has his premium reduced by 15 to 100 %.

In principle the men whose work and supervision affects several sections, are granted an average premium based upon the output of the different yards in the work of which they take part.

In the event of extreme cold, the calculations of the premiums for good work is corrected by coefficients proportional to the lowering of the temperature below 32° F.

The premiums for good work are paid monthly after their total has been brought to the notice day by day of the men affected.

In certain cases (Champigneulles Station), the premium for good output indicated above, has been extended to the whole of the yard, but, owing to the slight importance of the yards, other than the shunting yard, the various yards have been considered as forming a single yard, which is granted premiums in the same way as the shunting yard.

### Midi.

Premiums for output are granted in certain stations in which the shunting is considerable. These premiums being reserved in principle to yards in which the formation and breaking up of ordinary goods trains takes place, shunting wagons into sheds, or on to off loading sidings, and feeding the various private sidings connected to the station.

The premium is granted to all men in the management and operating side of the shunting properly said, and to the signalmen.

The hourly premium of a man in a gang is given by the formula :

$$P = 2\frac{w}{w_0} - \frac{a}{a_0} - \frac{v}{v_0}$$

in which :

$w$ = the number of wagons dealt with in the yard monthly;

$w_0$ = the number of wagons on the average dealt with in the yard during the same month;

$v$ = the number of hours per month of shunting engines (15 minutes shunting as a quarter of an hour, 30 minutes : as half an hour);

$v_0$ = average monthly number of engine shunting hours during the base month;

$a$ = montly number of men hours including the foreman shunter, without distinction of grade;

$a$ = average monthly number of men-hours up to foreman shunter without distinction of grade during the base month.

The quotients $\frac{w}{w_0} \cdot \frac{a}{a_0}$ and $\frac{v}{v_0}$ are calculated to three decimal points.

The gross hourly premium of a labourer is equal to $p$.

The nett premium is equal to the gross premium if $p$ is less or equal to 0.30.

If the gross premium is higher than 0.30, it is reduced by half the set in order to obtain the nett premium $p'$.

If the premium $p'$ is above 0.40, it is reduced by half the further increase in order to obtain the final premium $p''$.

The premium $p''$ of a labourer being

thus ascertained, the hourly premiums of the other men are :

| | |
|---|---|
| Charge hands | 1.2 $p''$. |
| Assistant foreman shunter | 1.5 $p''$. |
| Foreman shunter | 2.5 $p''$. |
| First foreman shunter | 3 $p''$. |
| Signalman | 0.9 $p''$. |
| Second class pointsman | — $p''$. |
| First class pointsman | 1.2 $p''$. |
| Head pointsman | 1.5 $p''$. |

The premiums are calculated monthly.

With this object the hourly premium is multiplied by the number of hours of work in which the man has been employed in shunting work during the month considered.

The premium of each man is subject to a reduction equal to :

Two hourly premiums per each delay in making up a train, having caused a delay of more than 10 minutes in getting the train away;

Two hourly premiums for each delay in shunting the dock sidings, shed sidings or private sidings connected with the station;

Three hourly premiums for each irregular formation of a train (wrong classification, improper brake action, resulting in the train being reformed before despatch etc.).

Four hourly premiums for each delay in despatching empty or loaded wagons, when the train which should have picked up these wagons, has left without them.

In addition, an exceptional reduction $r_1$ for a serious mistake can be made as an exceptional punishment, either from all the staff in the gang, if the mistake is common, on from one of the men, if this man is solely responsible for the mistake committed.

The premium for the foreman shunters and head foremen shunters, can also be reduced by :

Three hourly premiums for each delay in forming the train, having caused a delay of more than 10 minutes in sending it off.

Four hourly premiums for each delay *not signalled,* in dealing with the despatch of empty or loaded wagons.

In addition, there is an exceptional reduction $r_2$ for various faults, which is imposed as an exceptional punishment.

The premium of the pointsmen in the yard, can be reduced by :

One hourly premium for rakes sent on the wrong line, when this is not due to a mistake in marking wagons, or for technical reasons (crossings occupied, slow speed of the wagons previously shunted off, etc.).

Two hourly premiums for each delay in forming the train, which results in a delay of more than 10 minutes in getting the train away.

In addition, an exceptional reduction of $r_3$ for serious mistakes can be imposed as an exceptional punishment.

### Nord.

For men engaged in shunting service in the large shunting yards, including the pointsmen, who actually take part in carrying out the work, and the men in the operating offices, a premium for good work is granted in about 30 important stations.

The premium is calculated separately for each of the yards at any one station, having its own staff and definitely laid out for the work.

It can be calculated for periods of 8 hours or a period of 24 hours.

It is granted after a minimum output and increases by steps according to the number of wagons actually shunted.

The special premium also varies according to the quality of the work, the reductions or suppressions being individual, if the author of the fault can be identified, and collective if not.

The premium is paid monthly, the amount having been brought to the notice of the staff concerned day by day. Whereas for the shunters, properly speaking, the pointsmen, and the number takers the daily premium is about 1.50 whatever the grade may be, it is increased by about a quarter (1.90 approximately) for the brakesmen.

*Men driving tractors or motor tractors used in shunting parcels barrows or shunting wagons.*

Most of the great French Railways grant a daily allocation of 1.50 to 2 fr. to the men driving and looking after the petrol motor tractors used for working the station.

The Paris, Lyons & Mediterranean also grants this premium to the men driving and looking after the electric stock, and to the men driving the parcels tractors in the large stations.

*Ticket issuing staff.*

In the stations Paris-Orsay, Paris-St-Michel, and Paris-Austerlitz, the Paris-Orleans Railway has instituted a premium of 0.0625 per ticket issued above a minimum annual number determined as follows :

| | | |
|---|---|---|
| Ticket staff. . . . . | 100 000 | per man. |
| Assistants . . . . . . | 80 000 | |

The number of tickets is obtained by giving each class of ticket a coefficient a function of the complication involved in making them out. The unit being the ordinary main line ticket the coefficients vary from 0.2 for platform tickets to 50 for circular or excursion tickets.

*Clerical staff.*

On the Est Railway, at Paris-Messageries, there is a system of premiums for good work, for the men dealing with the consignment notes in order to insure that all express parcels traffic leaves regularly by the proper trains.

The collective gratuity is calculated in terms of the saving realised for the whole of the staff concerned; this gratuity is distributed prorata with the savings effected by each of the men. The collective premium and the individual premium are based upon the relation between the time actually taken in preparing the consignment notes, and the theoretical time allocated for carrying out this duty. There is an increase in premium for the principal clerks, and for the chief clerks and their assistants.

The premium can be reduced for any mistake, or bad work reported; on the other hand the supervisor recording this mistake, or incorrect work, benefits by an increase on his individual premium.

*Men looking after batteries for certain track instruments.*

On certain of the French Railways (the Paris, Lyons & Mediterranean in particular) the men who look after the batteries are granted a premium of 1 fr. per day worked on the batteries.

*Men working parcels trains or slow speed pick up trains on a busy service.*

The Paris, Lyons & Mediterranean grants a daily premium of 1.25 fr. per day's work to the guards, and 0.65 to the other men (conductors or wagon men).

### *Pointsmen and signalmen.*

The Belgian National Railway Company, grants a quarterly premium of 30 frs. to men in very important signal boxes, and 24 frs. to the men in boxes of medium importance, with a reduction of the premium if the service of the men concerned is not satisfactory during the quarter.

### *Lighting staff.*

The Belgian National Railway Company has granted various premiums in order to induce men looking after or supervising lighting to reduce the cost thereof.

For example :

*a*) premiums for economies in the cost of lighting by incandescent lamps using parafin;

— premiums when the lamps work properly, 0.03 per lamp per day of proper working, with penalties of 0.30 per lamp the working of which has been found to be defective;

— premiums for economies of materials, equal to 1/4 of the saving effected, in relation to the theoretical allocation;

*b*) Premiums for economies in the cost of the lighting service for lampmen and foremen lampmen;

*c*) Quarterly premiums for the supervisors and heads of the lighting gangs based upon the number of visits carried out or for transfer duty of not less than 2 hours consecutively carried out during the night;

*d*) Quarterly premium granted to the station masters for saving in the consumption of gas, 0.03 per cubic meter of gas saved;

*e*) premiums for the maintenance of the electric light equipment on the carriages, 0.10 per inspection of an ordinary carriage, 0.15 for the inspection of a bogie carriage, saloon, post office van, etc., with penalties of 1.50 for any bad working found in the lighting. These premiums are distributed prorata, to the number of hours of work of each of the men concerned, with the coefficient which takes into account their grade.

### *Various.*

On the French Nord Railway, men in the operating department, are granted a premium of 0.50 fr. per kilogramme of waste cordage or lead, and 0.15 fr. per kilogramme of coupling links that these men recover during their daily service.

# CHAPTER III.

## PREMIUMS AND GRATUITIES GRANTED TO EMPLOYEES IN THE ROLLING STOCK AND LOCOMOTIVE RUNNING DEPARTMENT.

## SECTION No. 1.

### Premiums and gratuities granted to locomotive enginemen.

The men affected by these premiums are the drivers and firemen of steam locomotives and also the drivers and assistant drivers handling electric locomotives.

In the case of the men handling steam locomotives, the premium of the firemen is a fraction of that due to the driver with whom he works. This fraction varies between 1/2 (Belgian National Railway Company) and 2/3 (Main French Railways).

Certain factors taken into account when calculating the total premium due to the driver, are not necessarily taken into account when calculating that due to the fireman (on the Belgian National Railway Company, the driver alone receives premium for oil saved).

In the case of electric locomotive drivers, the assistant is granted a fraction of the premium of the driver he works with (Midi Railway — fraction 2/3) or a fraction of the average total premium of the electric locomotive drivers of the district; (Paris-Orleans Railway — fraction 2/3) certain personal premiums (mileage reserve duty in the depot) being ignored.

The pay of the men is increased on the average through these premiums :

In the case of the drivers : by 34 % for the Main French Railways, and 12.5 % for the Belgian National Railway Company;

For the firemen : by 31 % for the Main French Railways, and 7.3 % for the Belgian National Railway Company;

For the electric locomotive drivers : 24 % for the Main French Railways;

For the assistant locomotive drivers : 19 % for the Main French Railways.

The staff agreement on the Main French Railways, lays down minimum values for the premiums in the locomotive running Department.

The method of calculating this premium is the same on all the Railway Systems : it consists in adding together the partial premium obtained for a certain number of factors. These factors are given below, as also the Railways that take them into account when making up the premiums due to their locomotive engine men.

A. — **Saving of fuel or traction current.**

The premium is based upon the difference existing between the amount allowed, and the actual consumption; the fuel is, as a rule, coal, and in certain particular cases, petrol or fuel oil.

### Belgian National Railway Company.

The gross quantities of fuel are calculated :

*a*) per kilometre run by the locomotive;

*b*) per kilometre run in shunting service;

*c*) per tonne-kilometre hauled.

The fuel allowed as well as the actual consumption are corrected to take into account, the relative values of the different kinds of coal (net allowed and theoretical consumption).

### Main French Railways.
### (Est.)

The kilometric allowances result from:

Train-kilometres, — shunting hours, — hours standing, — light-kilometres, — overload, — time made up, — heating (kilometres of heated train)

(The allowances varying with the service and parts of engine.)

An additional allocation is granted to assure an average economy per km. in the case of engines on any one working.

### State Railways.

The allowance is the total quantity of fuel or of electric current required by the engine to which is added that corresponding to the tonnage hauled.

### Midi.

The allowance per kilometre includes :

— the principal allowance corresponding to the normal tonnage;

— a supplementary allowance corresponding to the increased or reduced tonnage, over or below the normal;

— an allowance for single engine, double heading, shunting, etc.

### Nord.

The allowances are fixed by class of engine according to the kind and load of the trains. A supplementary premium is granted to men using mixed fuel instead of briquettes.

### Paris, Lyons & Mediterranean,

The normal allowances of fuel are fixed :

— For the ordinary train working :

Two parts : one corresponding to the friction to be overcome (proportional to the distance); the other corresponding to the rolling resistance (proportional to the ton-kilometres).

— for shunting (hourly rate);

— for time standing in steam;

— for lighting up;

— for each minute made up.

To these stated allowances is added a supplementary allowance granted to the whole of the drivers of one series, in order to assure to them a certain minimum premium.

### Paris-Orleans.

#### *Steam trains.*

The allowance of fuel results :

— from the hours the machine is standing in reserve;

— the kilometres worked single engines;

— the kilometres covered in shunting;

— the tonnage of the train hauled;

— heating the trains.

In addition, a supplementary allowance is granted to ensure the engines working the same service, receiving a certain minimum premium per 1 000 km.

The allowance corresponding to the extra tonnage is double or triple (according to the extent of the extra load).

### Electric working.

The monthly allowance of traction current is calculated per 100 tonne-kilometres, applied to all the men on the same working, so that those men who have done this work, and who are grouped together in the average from the point of view of consumption, receive a fixed premium per 1 000 km. of the conventional distance.

### Other Railway Systems.

### Metropolitan.

The Deux-Sèvres, Haute-Saône, Haute-Savoie, Indre, Jura, Landes and Tarn Systems, have introduced premiums for fuel saving based upon allowances varying with the distance and sometimes also with the tonnage hauled.

In addition to these premiums, the Haute-Saône System grants supplementary premiums, to those drivers who at the depots on the Railway, are found amongst the best as regards the quantity of coal used.

The Jura System has also introduced premiums for saving current.

The Société des Transports en Commun de la Région parisienne grant to the tramway drivers, a premium for current saved based upon a daily value of the current consumed.

### Colonial Railways.

The Algerian Lines of the State, the Tunisian Railways, the Gafsa Railway, the Dahomey Railway, the Conakry to the Niger Railway, and the Réunion Railway, grant premiums for fuel saved based upon factors similar to those in use on the great Railways, that is to say, distance run either when working trains or light, tonnage hauled, time spent in shunting, time standing in steam or pilot.

### B. — Saving on oil.

Those Railways who have introduced this factor in the premiums allow as a rule, a fixed premium per kilogramme of oil saved in relation to the amount allowed.

### Belgian National Railway Company.

The quantity of lubricating material is allowed in terms of a standard oil per kilometre run.

### Main French Railways. Est, State, Midi, Nord, Paris, Lyons & Mediterranean, Paris-Orleans.

The allowances fixed on these Systems, as regards lubricating and cylinder oils, are based upon the mileage run and the class of engine.

### Other Railways.

### Home Railways.

The Deux-Sèvres, Haute-Savoie, Indre, Jura, Landes, and Tarn Systems, grant premiums based upon oil saved.

### Colonial Railways.

The Algerian Lines of the State, the Tunisian Railways, the Gafsa Railway, the Dahomey Railways, the Conakry to the Niger Railway, and the Réunion Railway grant premiums for oil saved.

### C. — Distance run.

**Main French Railways. Est, State, Midi, Nord, Paris, Lyons & Mediterranean, Paris-Orleans.**

These Systems grant a premium based upon the actual distance run, the amount of which varies according to the service. The Nord Railway, adds to the premium per kilometre, an amount proportional to the period of actual work. The Paris, Lyons & Mediterranean System add to the kilometric premium, an increase reserved to the drivers, or firemen on train working after a certain period of service in their grade.

The amount of this augmentation increases with the years of service.

The value per 1 000 km., of conventional monthly distance run, in use on the Paris-Orleans System, is progressive, that is to say, it is the higher as the difference run is greater.

**Other Railways.**

**Home Railways.**

The Tarn System grants a premium proportional to the actual distance worked.

**Colonial Railways.**

The Algerian lines of the State, the Tunisian Railways, the Gafsa Railway, the Dahomey Railways, the Ivory Coast Railways, the Thiès to the Niger Railway, grant mileage premiums.

### D. — Time made up, time lost.

As a rule, the Railways granting a premium for time made up also reduce it for time lost.

**Belgian National Railway Company.**

The premium or penalty varies according to the difficulties of working the train (2 classes of trains). The penalty per minute lost is higher than the premium per minute gained.

**Main French Railways. — Est, State, Midi (steam working). Nord, Paris, Lyons & Mediterranean (steam working). Paris-Orleans (steam working and electric working.)**

These Railways apply premiums or fines, varying with the kind of train and, as a rule, with the class of working.

The fine per minute lost is, as a rule, greater than the premium per minute gained.

The Paris, Lyons & Mediterranean Railway, takes as the basis when calculating the time gained, not the difference between the time taken and that of the time table, but the difference between the time taken and the time required to work the distance at the possible speed of the train, calculated from the load of the train, and taking into account the limiting speed of the line.

The value per minute gained is progressive, the time per minute lost is fixed and is equal to the lowest premium granted per minute saved.

The Paris-Orleans applies a variable premium according to the actual load hauled as compared with the standard load.

**Midi (electric working) and Paris, Lyons & Mediterranean (electric working).**

The Midi and Paris, Lyons & Mediterranean Systems, do not grant premiums for time gained to men working electric locomotives, but apply, on the other hand, a fine if time is lost.

On the Midi System, this fine is a money fine per minutes lost. On the Paris, Lyons & Mediterranean System, the punishment consists in holding back, in case of loss of time, the premium for regular running (see further on).

#### Other Railways.

#### Colonial Railways.

The Algerian lines of the State and the Tunisian Railways, have introduced premiums or fines for time gained or lost.

The Dahomey System only applies fines for time lost.

### E. — Work done.

#### Main French Railways.

#### Est.

This System is considering fines for serious delays, failures, etc.

#### Midi.

*Steam working:* Any failure of the engine causing a delay of more than 15 minutes; lack of power, or failure of the engine result in fines.

*Electric working:* A premium of good working taking the place, for the electric drivers, of the mileage premium, has been instituted by multiplying the distance run in kilometres by a premium for good service fixed by the Chief Engineer of the Rolling Stock and Locomotive Running Department.

A fine is applied for any incident that the driver could have avoided.

#### Nord.

An increase in the running premiums is allowed to the men working fast express trains who have during a quarter, worked the trains without having in any way done anything against safe working.

This increase is about 12 % in the first quarter; increases by 1 % per quarter of good service up to a maximum of 20 %.

In the event of anything done against safety, the increase in the premium is suppressed for the quarter in question, and the percentage to be used for the following quarter, is reduced to 12 %.

#### Paris, Lyons & Mediterranean.

*Steam working* : A special premium for drivers of the express trains is especially granted to the men whose monthly kilometrage exceeds 10 000 and who have worked their trains properly.

*Electric working :* A premium for regular running granted to the electric drivers in the case of the trains where nothing has gone wrong, and when they have made up, if late, the time that they can possibly regain.

#### Paris-Orleans.

A distance of 30 000 km. (18 640 miles) on goods trains without any breakage of couplings, entitles the driver to an increase of the kilometrage premium.

Professional mistakes, the use of pilot engines when not neccessary, result in special fines being inflicted.

#### Other Railways.

#### Home Railways.

The Tarn Railway grants a mileage premium for the proper handling of the locomotives which can be reduced or even cancelled, in the event of damage attributable to the enginemen.

### Colonial Railways.

The Algerian State System grants a premium for regularity of working (supplement as a percentage of the running premium) which varies according to the work carried out, to the drivers who have not received any severe punishment.

The Gafsa Railway awards a monthly premium to the drivers working goods trains; this premium is reduced in the event of any defective working.

The Thiès to the Niger and Conakry to the Niger Railways impose a fine for professional misconduct.

## F. — Maintenance of the rolling stock.

### Belgian National Railway Company.

A daily premium known as « conservation des moteurs » is granted to every engineman working with one locomotive a minimum uninterrupted service, of from 10 or 15 days (according to the service).

### Main French Railways.

#### Est.

This Railway has instituted a premium for maintenance, based upon the distance run between two heavy repairs. The value upon which this premium is based, is progressive; it varies with the class of engine.

#### Nord.

Monthly premiums are granted to the firemen who distinguish themselves by the care given to the cleaning of their engines.

#### Paris-Orleans.

When the distance run by steam locomotives between two heavy repairs is increased beyond a minimum, an increase of the mileage premium is given.

The cleaning of the locomotives by the enginemen, is rewarded by a fixed increase.

### Other Railways.

#### Home Railways.

The Haute-Savoie System grants maintenance premiums varying according to notes taking into account the state of maintenance and cleanliness of the engine.

The Haute-Saône Railway awards fixed premiums to the gangs in certain depots who are at the top of the list as regards the maintenance of the locomotives.

#### Colonial Railways.

The Tunisian Railways and the Gafsa Railway award premiums based upon the cleanliness of the engine.

The Thiès to the Niger Railway awards a maintenance premium based upon the number of kilometres run, according to the type of locomotive.

The Réunion Railway awards a maintenance premium based upon the duration of the service carried out.

## G. — Various factors.

### Main French Railways.

#### Est.

This Railway has instituted an hourly premium for work in the shed or shunting in the station.

In cases in which station shunting is carried out by engines worked by a single man, the total premium granted to this man is increased by 50 %.

There is also a premium for speed in replacing a defective engine, and a premium for leaving at short notice granted in the case of a man doing sedentary work who has to go out on to the road.

### Nord.

Certain surburban trains and certain heavily loaded trains, give rise to the grant of an increase in the premium when they are satisfactorily worked.

### Paris, Lyons & Mediterranean.

This System has instituted a special premium for men working ballast trains which take into account the fact that these men do not participate in the premiums mentioned above.

This Railway has also instituted special premiums for drivers and firemen on shunting duty. A supplementary premium is granted to drivers covering shunting in stations without à fireman.

### Paris-Orleans.

This Railway grants an hourly premium to sets of men in reserve in the shed.

### Other Railways.

### Home Railways.

The drivers of the Société des Transports en Commun de la Région parisienne (Paris to Arpajon line) receive a premium calculated by the formula.

$$P = \frac{N \times 0.015a}{20}$$

$N$ = kilometres run,

$a$ = a note of merit according to the service worked.

The Tarn Railway awards a premium for savings of cleaning rags (allowance per kilometre).

## SECTION No. 2.

## Premiums and gratuities granted to train examiners.

These premiums affect the examiners and also, as a rule, the leading examiners.

The formulæ used to calculate this premium is given below :

### Main French Railways.

The Staff Agreement in use on all the main French Railways provides for the grant of a monthly premium of supervision to the train examining staff, the amount of which can be increased or reduced, in relation to the quality and the results of the work done by each man.

The main railways have agreed to use the following formula :

P (actual premium paid) = $P_s \times K$.

$P_s$ is the legal premium laid down for each of the men;

K represents the expression $\Sigma\ k$;

K designating each increase in % corresponding to a defect discovered by the man and which affects the safety : bent or cracked axle, cracked tyre, loose wheel, etc.; a scale fixes the amount of increase of the premium according to the defect discovered.

K can also represent the reduction in % of the premium for failing to carry out duty, careless examination, etc.

In addition to this premium, certain of the main Companies award premiums based upon the formulæ shown below :

### Est Railway.

This system has instituted a supplementary increase of the normal statutary premium $P_s$ which is calculated by the formula :

$$P = K \times P_s \times J \frac{V - \alpha \times n}{V}$$

in which :

$K$ = coefficient;
$J$ = number of days on examination duty;
$V$ = the number of vehicles or of trains examined (according to the station);
$\alpha$ = coefficient depending upon the number of men at the station considered, and upon the number of vehicles, or of trains leaving the marshalling yard, or of vehicles repaired.
$n$ = number of examiners at the station.

### State Railways.

These Railways award an increase for the whole of the staff at a station, which is determined in regard to a note of merit awarded to each examining centre.

### Paris-Orleans Railway.

Certain defects which do not immediately affect safety receive increases (in francs) the value of which is a function of their importance, and of the ease with which they could be seen, under the condition, however, that the total number of defects reported monthly is greater than 3.

### Other Railways.

### Colonial Railways.

The Algerian Railways of the State awards premiums for supervision which can be increased or reduced according to the work done by the man (no formula has been applied).

The Lower-Congo to Katanga Railway awards a premium based upon the number of trains to be examined; special premiums are awarded in the event of serious defects being discovered.

⁂

The pay of examiners and leading examiners is increased as a result of the premiums mentioned above, by 6 to 12%.

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## SECTION No. 3.

## Premiums and gratuities granted to workmen and labourers in various works (sheds, repair shops, workshops, stores, yards, etc.).

### Belgian National Railway Company.

### I. — *Premium for repairs to the locomotives.*

A collective premium is awarded to the leading workmen, workmen and labourers engaged in the maintenance of the locomotives, and distributed in prorata to the number of hours of duty and in accordance with the grade of the man.

This premium depends upon the four following factors :

1. A certain percentage (varying with the shed) of the premium for keeping the locomotives in good order;

2. 1/2 % of the saving of fuel at the depot;

3. 10 % of the saving of labour in repairs calculated upon certain agreed standards, reduced by 10 %;

4. 20 % of the material saved in repairs, in comparison with 1925 (taking into account the increase of staff since 1925).

No account is taken, when calculating the premiums, of factors which can be negative.

### II. — *Premiums for the amount of work done.*

Two cases are considered according as the workman works on his own, or in a gang.

1. For a workman working alone :

The monthly premium is :

$$\frac{\Sigma t_1 - \Sigma t_2}{2} \times Sm.$$

$\Sigma t_1$ = total time allowed,

$\Sigma t_2$ = total time taken,

$Sm$ = mean hourly pay of the group.

2. For a workman in a gang :

The monthly premium is :

$$\frac{\Sigma T_1 - \Sigma T_2}{2\Sigma T_2} \times \Sigma t_2 \times Sm.$$

$\Sigma T_1$ = total time allowed for the whole gang,

$\Sigma T_2$ = total time taken by all the men in the gang,

$\Sigma_2 t$ = total time taken by the workman considered,

$Sm$ = average rate of pay.

The workmen whom it is not practicable to allow to share in the premiums (tool makers, for example) benefit by a premium based upon a similar formula in which $\Sigma T_1$ and $\Sigma T_2$ relate to a section of the shop which may be different to the gang.

The price for the work is agreed between the immediate Head and the shop committee.

The premiums paid to the men increase the total pay by 16 % on the average.

### **French Railways.**

### **Est.**

### *Locomotive depots.*

A gratuity calculated quarterly is granted to workmen in the depots, the grant being a function of the output given.

One of two methods of calculation are used, according to the work upon which the man is employed :

#### 1. *Running repairs.*

The gratuity consists of two parts

*a*) Gratuity relating to time work;

$G = a \, \Sigma \, A$;

$a$ = hourly rate fixed for the depot;

$\Sigma \, A$ = total time allowed to the men during the quarter.

This round gratuity G is distributed amongst the whole of the men concerned, prorata with the difference between one and a half times the total of the time allowed to each, and the total of the hours taken to carry out the work.

*b*) Gratuity relating to work for which no time is fixed, an hourly gratuity equal to $\frac{a}{2}$.

#### 2. *Periodical repairs and maintenance of machine tools, forge equipment, etc.*

*a*) Gratuities relative to booked work.

$G_1 = p \, \Sigma \, A$;

$p$ = hourly rate fixed by depot.

This total gratuity is distributed between the labourers, fitters labourers, tradesmen, assistant charge hands, charge hands (see chapter I, section 2) in proportion to the difference between one and a half times the total of the time allocated to each of them, and the total of the time taken to carry out the work.

The basic gratuity so obtained is multiplied by a coefficient varying with the grade.

*b*) Gratuities relating to work for which there is no price fixed :

Hourly gratuity equal to $\frac{P}{E}$

P = Monthly gratuity of the man concerned when working at time rates,
E = corresponding time taken to do the work.

*Maintenance gangs.*

A gratuity calculated monthly for each individual is allocated to the men dealing with maintenance work.

When calculating this gratuity, according to the work done, two cases arise :

*a*) Work for which a fixed time is allowed :

Hourly gratuities :

$$p = 2 \text{ fr.} \times \frac{A - E}{A} \times E$$

A = sum of the time allowed during the month to the workman,
E = corresponding time taken to do the work.

This gratuity is consequently based upon the output obtained.

*b*) Work for which no time is fixed :

Hourly gratuity :

$$g = \frac{1 \text{ fr. } 25}{2} \times R.$$

$$R = \frac{K\Sigma A - (\Sigma E + \Sigma M)}{K\Sigma A}$$

$\Sigma$ A = Total of the times allowed to the men during the month on work for which a price is fixed.
$\Sigma$ E = corresponding time taken to carry out the work.
$\Sigma$ M = the total of the time spent in doing work for which no time is fixed,
K = coefficient varying with each Works.

The object of this gratuity is to induce the workmen to diminish the number of hours spent on work for which no times are fixed.

*Main carriage, wagon and locomotive workshops.*

The workmen in the main carriage wagon and locomotive workshops, are allocated a collective gratuity calculated quarterly, based upon the output of the shops, and of the section of the shop to which the workmen belong, as well as upon the proportion of time spent on work for which time allowances are fixed. This collective gratuity is based on an hourly gratuity equal to :

$$P_1 = p\left(1 + \frac{n}{100} + \frac{t}{1\,000}\right).$$

*p* : is given by the formula :

$$p = \frac{\Sigma A - \Sigma E}{\Sigma E} \times 150 \text{ fr.}$$

in which :

$\Sigma$A = total of the time allowed for all the work listed in the quarter for the *whole* of the sections of the main workshop.

$\frac{n}{100}$ is calculated by the formula :

$$\frac{n}{100} = \frac{g}{t^a} - m$$

in which :

$g$ = time saved } for each *section*
$t^a$ = time allowed } of the works,

$m$ = mean value realized for this ratio in 1920.

$\frac{t}{100}$ is calculated by the formula :

$$\frac{t}{100} = \frac{Ta}{Ta + To} - K$$

in which :

$$\frac{Ta}{Ta + To} = \frac{\text{Time spent on work for which time is fixed}}{\text{Total work time}}$$ for each *section* of the works.

K = the mean value for this ratio in 1920.

The total of this premium can be affected by penalties inflicted personally for bad work, waste of time, etc.

The annual gratuity of the workmen is equal to :

Depots : 1 000 fr. — Repair points : 650 fr. — Workshops : 850 fr.

The present system of premium was instituted in 1918, in the main workshops, when the old piece prices, previously in use in these workshops, were changed over to time allowances.

The premiums now in use in the depots and repair shops, were introduced in 1924 at the same time as the modern principles of organization of work in all the shops of the rolling stock and running departments, was introduced.

The time allowed for doing the work was arrived at from data collected during a whole year.

Since 1924, the whole of the time allowed has been arrived at by breaking up the work into the elementary operations, and recording the time taken to carry them out.

It is estimated that in a main workshop 12 to 15 % of the work done can not be done to a time allowance.

The time allowed is entered on the work note beforehand, by a clerk or the leading hand after the work office has determined in detail, the work to be done.

### State Railways.

### *Locomotive depots.*

The workmen in the depots benefit from an hourly premium given by the formula :

$$p = \frac{T - t}{T} \times s$$

in which :

T = total time agreed with the gang for lifting a locomotive (varying with the class and the number of kilometres run),
$t$ = time taken to lift the engine,
$s$ = imaginary pay (less than the hourly rate) per grade of man.

### *Main workshops and repair shops for rolling stock.*

The workmen engaged upon repair work and in the main workshops are granted an hourly premium given by the same formula as that used for workmen in the depots :

$$p = \frac{T - t}{T} \times s.$$

However :

T and $t$ represent in this case, the sum of the time fixed and taken for work done by a workman,
$s$ has the same definition as above.

Originally, the times allowed were obtained by conversion of the old piece work prices.

Today, times are taken, but without breaking up the work done into its basic part.

The times allowed for the whole of a job, are fixed by a careful study of the matter before consulting the men who will have to do the work.

The proportion of the staff working on premium, varies from 25 % (sheds) to 92 % (shops) of the total staff.

The total pay of the workmen is increased from 4.5 to 7.5 as the result of these premiums.

### Midi Railway.

#### *Main carriage, wagon and locomotive works.*

The workmen in the main works are granted an hourly premium the amount of which is calculated by the formula :

$$p = \frac{T - t}{T} \times s$$

in which :

T, *t* and *s* have the same meaning as above (State Railways, case of the main workshops).

The times allowed as from 1921, were obtained by converting the old piece prices.

The times now applied, are taken by direct measurements carried out by the management staff. The time allowed is calculated from the formula :

$$\frac{T - \frac{11t}{10}}{T} = 0.20$$

T = time taken by a good workman.

The times allowed are arrived at by means of a statement after considering the work to be done prepared by the chargeman and the works manager, or by the chargehand alone.

Most of the premiums (excepting, for example, welders) are calculated per gang and the chargehand, or assistant chargehand shares in the premium.

The proportion of the men working under premiums varies between 88 and 100 % of the total staff.

The pay is increased on the average by 7 %.

### Nord.

#### *Depots and main workshops (locomotives).*

Premiums on the output are granted to the gangs, assistant chargehands, and erectors and fitters dealing with the repairs of locomotives, and calculated by the formula :

$$P = K \times \frac{T - H - R}{T} \times H$$

in which :

P = individual hourly premium,

T = time allowed for the repair of an engine,

H = hours taken by the workman concerned on the repairs to the engine,

R = marks withheld as punishment based upon additional adjustments found necessary during a certain guaranteed distance,

K = a varying coefficient according to the grade (from 1.40 for the fitters assistant to 2 for the assistant chargehand).

#### *Main workshops (carriages and wagons).*

A premium on output is granted to the assistant chargehand, workmen and labourers, working on general repairs to certain types of carriages or wagons.

The repair of a vehicle is compared with that of a typical repair taken as unit corresponding to 820 hours of work (carriages) or 296 hours of work (wagons). Each of the men in the gang is granted an increase of pay equal to $\frac{75}{82\ 000}$ (carriages) or $\frac{75}{29\ 600}$ (wagons) per hour made up.

### Paris, Lyons & Mediterranean.

#### *Locomotive depots.*

1. Repairs, maintenance and alterations work.

Workmen occupied with work of this class, are granted an hourly premium calculated by the formula :

$$p = \frac{T - t}{T} \times \pi.$$

T and $t$ are the times allowed and taken on the different parts,

$\pi$ is the hourly base rate including the premium for the work.

This is therefore a case of the Rowan system of pay.

The organization of the work was taken in hand in 1920 and developped during the following years.

2. Machine tools operators and similar grades.

These men are granted a premium based upon the total $\Sigma T_L$ and $\Sigma T_E$ of the time allowed in the depot for the work done in the month, to the men occupied in lifting and maintenance of the locomotive (erectors, fitters, etc.).

If $\Sigma\, t$ is the total of the time taken during the month by the machine hands and such men (turners, drillers, smiths, boiler makers, etc.), and $\Sigma\, f$ the total of the time taken on work other than lifting and ordinary repairs, the following calculation is made;

$$m = \frac{(a\Sigma T_L + b\Sigma T_E) \quad (\Sigma t - \Sigma f)}{a\Sigma T_L + b\Sigma T_E}.$$

Each man receives a part of the premium equal to : $m\ (t - f)$ S (S = pay of this man).

3. Workmen responsible for examining engines in service.

These men receive an individual daily premium based upon the average number of supposed engines (coefficient for correction by the class of engine) visited in excess of 14.

In addition a gratuity is granted for any discovery of an important fault which is difficult to see; on the other hand, reductions are made in the event of anything happening for which the examiner is held responsible.

#### *Repair shops and main workshops.*

An hourly premium is allocated to those men :

$$p = \frac{T - t}{T} \times \pi$$

in which :

$\pi$ is, as above, the hourly rate of pay for a workman; this formula is therefore the same as the Rowan system.

As a rule the bonus is calculated per gang; it is calculated individually for certain workmen working by themselves.

This system was instituted in 1921.

The times allowed T were obtained either by converting the old piece work prices in force before 1917, or by timing the operation; certain special work cannot however be brought under these premium systems.

The work to be done is determined by the management staff itself.

The creation in the future of special offices to deal with the calculation of time, allowances, and the introduction of repair sheets to be filled up in accordance with expert advice before taking in hand the repairs, is under consideration.

Taking the whole of the Rolling Stock and Locomotive Running Department, the introduction of these premiums has resulted in the pay of the men being increased by from 14 to 28.5 %.

### Paris-Orleans.

### *Locomotive depots. — Repair shops. — Main locomotive workshops.*

In all these works, the men are given an interest in their output by an hourly premium which is calculated by the formula :

$$p = \frac{T - t}{T} \times s.$$

T, $t$ and $s$ have the same meaning as above (State Railways, case of the main workshops).

The bonus is calculated individually wherever possible, otherwise, per gang.

The present premium system was instituted in 1921.

The whole of the times allowed T are arrived at either by timing or by applying a scale after the various jobs have been broken up into their basic operations. The preparation of these times was at the same time accompanied by improvements in the method of doing the work.

The times allowed calculated in this way, are applied to the whole of the work done in the workshops.

The proportion of men working under the premium system in relation to the total staff, increases as the methods of carrying out the work are revised : the highest proportion will be about 80 %.

The total pay of the men has increased by 10 % as a result of these premiums.

The institution of these premiums for output, was only put into force in the main workshops after the complete reorganization of these latter upon rational bases, a reorganisation in which the methods of Taylor and of Fayol were used as the basis, and a description of which is outside the scope of the present report.

## OTHER RAILWAYS.

### Home Railways.

### Société de Transports en commun de la Région parisienne.

#### 1. *Manufacturing establishments.*

The formula for pay applied is that of piece work, the hourly gain is calculated individually or per gang.

#### 2. *Repair shops. — Depots.*

The workmen and watchmen are granted an hourly bonus based upon a note calculated fortnightly.

### Light Railway Company (Haute-Saône System).

The gangs in the boiler shops are granted a special gratuity in cases in which they carry out certain work.

### Colonial Railways.

### Algerian Lines of the State.

The workmen, chargehands, and assistant chargehands, receive an hourly premium based upon the formula :

$$p = \frac{T - t}{T} \times s$$

T, $t$ and $s$ have the same meaning as above.

The times allowed T are fixed by the foremen.

The individual pay has been increased by 7 % as a result of the premium.

### Tunisian Railway Company.

The working staff receive premiums calculated individually as follows :

$$P = p + \frac{8p \times n}{100}.$$

The first term : $p$ is a daily premium for work the base value of which is fixed for each grade of workman and which can vary according to a monthly figure based upon the work carried out. (For men not working task work, this premium can vary up or down by tenths in terms of the output).

The second term : $\frac{8p \times n}{100}$ is an extra premium paid to men on task work.

$$\left(\frac{n}{100} = \frac{\text{time saved}}{\text{standard time}}\right).$$

It should be noted that $8p$ corresponds to the average pay of the men of each grade.

The result of this is that the total pay : $S = So + P$ is approximately the Rowan system of payment.

The times allowed were obtained first of all by converting the old basic prices.

The new times have been determined so as to bring the premium back to 10 % in each section of the shop.

The total times allowed for the various jobs, shown on the repair notes, are obtained before any work is done by the repair men.

The pay is increased by these premiums by 22 %.

### Gafsa Railway.

The workmen in the workshops receive a premium :

$$P = s \times \frac{T - t}{T}.$$

T and $t$ have the same meaning as above, $s$ is the rate of pay of the workman.

The time allowed are obtained by careful timing.

Individual pay has been increased by 10 %.

### Upper Congo to the Great African Lakes Railway.

The erection of new stock entitles the staff to general premiums.

For repairs to rolling stock, the times and two thirds of the saving effected are allowed to the men concerned.

### The Dahomey Railway.

A half-yearly block premium varying with the number of days taken on the repairs of the locomotives, is granted.

## SECTION No. 4.

### Premiums and gratuities granted to the labourers in the various works (depots, repair shops, workshops, stores, coal yards, etc.)

In many cases the Railways award to the labourers in certain works, premiums on the same system as those granted to the workmen, the same formulæ being used; a number of the co-efficients, however, can be varied so as to adjust the total of the premium paid to the salary of this class of men.

We give below the Railways which work in this manner, if only for certain classes of labourers, showing the variations which may exist in methods of applying the formulae adopted.

As regards the formulae themselves, we would refer to Section 3 of the present chapter.

**Belgian National Railway Company.**

The labourers are granted a particular coefficient in distributing the collective premiums for maintenance of the locomotives.

**Great French Railways.**

**Est.**

*Locomotive depot workshops :* The labourers are given a special coefficient in accordance with the total premium due to the men carrying out periodical repairs.

*Maintenance :* These men, as a rule do not carry out any work for which time is fixed, and receive an hourly gratuity equal to :

$$g = \frac{1\text{ fr. }25}{25} \times \text{R}.$$

*Main workshops :* In the case of labourers in the main workshops, the hourly base premium $p$ used in the calculation for the workmen, is replaced by :

$$p' = p \times \frac{\text{N}a + 2/3\,\text{N}o}{\text{N}a + \text{N}o}$$

in which :

$\text{N}a$ = time taken by the labourers on booked work,

$\text{N}o$ = time taken by the labourers on work not booked.

**State.** — Dépots, repair shops, main workshops.

The imaginary salary $s$ used in the formula applicable to the workmen, is given a suitable value for each class of man.

**Midi.** — Main works shops.

Same remarks as for the State Railways.

**Nord.** — Main workshops (carriages and wagons).

Same formula, and same methods of application as for the workmen.

**Paris, Lyons & Mediterranean.** — Main workshops.

The labouring work in the workshops, is carried out by gangs of labourers working on the premium system according to the Rowan formula applied to the workmen.

The times allowed to the labourers are determined as shown below :

— for labouring inside the sections of the shop : a fraction of the hours taken by the workmen in the section (coefficient varying per section);

— for labouring from one section and another : a fraction of the hours taken by the labouring gang for the whole of the sections;

— for the sections : wheels, park, stores, etc. : time allowed per ton, per wagon, etc.

### Paris-Orleans. — Main workshops and central stores.

Same remarks as in the case of the State Railways.

## Other Railways.

### Colonial Railways.

Algerian Lines of the State.
Tunisian Railways.
Gafsa Railway.

These Railways, grant the labourers premiums calculated in the same way as in the case of the workmen.

⁂

The Railway Systems which grant to their labourers, and to certain classes of labour, premiums which differ by their method of calculation from those granted to the workmen, are given below :

### Main French Railways. — Alsace-Lorraine System.

The staff responsible for dealing with coal at the depots, is given an interest in the output in the following way :

Each month the hourly expected output is calculated by :

$$t = \frac{T \times 8}{N}.$$

T = The desired tonnage reached by the gang (calculated from the actual tonnage by multiplying it by a correcting coefficient which varies with the methods of handling the coal available).

N = Total number of hours spent in handling the coal.

if $t$ = 14 tons a premium is granted, its value being fixed by a progressive scale.

The chargemen and assistant chargemen of the gang, share in this premium to a sum equal to that of the labourers.

The individual pay is increased on an average by 4.5 %.

### Est.

*Work done inside the depots.*

The labourers employed in handling fuel, are granted premiums calculated in a similar way to that in use on the Alsace-Lorraine System.

A table fixes the hourly premium to be allocated per imaginary ton handled beyond a minimum of two tons; the imaginary tonnage is calculated from the actual tonnage by a coefficient which takes into account the means available (increase of 10 % for night work, and of 50 % for the days when the temperature falls below —5° C. [23° F.]).

The labourers employed on washing out boilers cleaning engines, lighting up engines, cleaning tubes receive a premium per engine washed, cleaned lighted up, etc., this premium varying with the class; the total claimed by the gang in a month is distributed between the men in prorata to the hours they are on duty, and the coefficient which varies with the post occupied in the gang.

The labourers not working on listed jobs, are given 60 % of the average hourly premium obtained by those engaged on cleaning, lighting up engines, and tube cleaning.

The chargemen, and assistant chargemen, of gangs of labourers, are granted an hourly premium for the duties on which they are engaged.

The premiums for washing out boilers, can be reduced if the work is badly done.

### *Lubricating axle boxes.*

The labourers responsible for axle box lubrication, receive gratuities calculated per center and distributed amongst the men at this center :

$$P = K \times N - K' \frac{N'}{N} n$$

K and K′ are coefficients varying with the place,
N = the booked number of greasers at the place,
N′ = the actual number of these men,
$n$ = the number of hot boxes booked against the center.

### *Main stores.*

The labourers in the main stores receive an hourly premium calculated by the formula :

$$p = 1 \text{ fr.} \times \frac{A - E}{E}$$

in which :

A = the total of the time allowed for handling material during the month;
E = total of the time taken to do the work.

The premiums distributed annually to the labourers vary between 240 and 1 200 francs.

## State Railways.

### *Locomotive depots.*

Coaling engines cleaning tubes, washing out boilers, result in premiums being based upon the quantities of work done.

### *Main workshops, and repair shops.*

The time taken by the labourers on work not listed, is given a premium calculated by the formula :

$$p = s \frac{(H - K) - h}{H - K}$$

in which :

$s$ = imaginary pay,
H = the number of hours monthly considered as sufficient to carry out the whole of the work the labourers are expected to do,
$h$ = the total time the labourers are on duty during the month,
K = the time spent on listed work.

## Midi Railway.

### *Locomotive depots.*

The labourers handling the fuel receive a premium based upon the tonnage dealt with; in order to calculate this premium, the real tonnage is converted into hourly expected tonnage : T (coefficient taken into account the means of handling the coal available) and an increase of 10 % is granted for night duty.

The hourly bonus per gang is equal to :

$$p = \left(1 - \frac{1.3}{T}\right) \text{fr.}$$

This amount is distributed between the men in accordance with the hours they are on duty.

No bonus is granted if : $T < 1.3$.

## Nord and Paris, Lyons & Mediterranean Railways.

### *Locomotive depots.*

Labourers dealing with coal receive a premium for daily output calculated according to the tonnage handled per man.

A scale fixes this premium after the actual tonnages have been compared with the expected tonnages (coefficients).

### Paris-Orleans Railway.

*Coal stacks and locomotive depots.*

The staff of a coal gang receives an actual premium based upon the tonnage handled.

In order to calculate this premium, the actual tonnage handled is converted into an imaginary tonnage (coefficient taking into account the appliances used).

The hourly premium varies with the imaginary hourly output. No premium is granted if the output is less than 2 tons.

Labourers on washing out boilers, receive a fixed premium based upon the number of engines washed out and referruled.

### Other Railways.

### Home Railways.

The Société des Transports en Commun de la Région Parisienne awards to the labourers in its manufacturing shops, a premium calculated by the formula :

$$P = T \times L \times K$$

in which :

T = time taken,
L = coefficient varying with the difficulty of the work,
K = coefficient a function of a note given by the Head of the Department.

* * *

As a rule, the increase of the pay of the labourers resulting from the institution of these premiums is similar in each Railway to that of the workmen.

# CHAPTER IV.

# PREMIUMS AND GRATUITIES AFFECTING PERMANENT WAY MEN

## SECTION No. 1.

## Premiums and gratuities granted to men on new work, inspectors, supervisors and maintenance staff of the track, buildings, and fixed plant.

### Belgian National Railway Company.

Daily premiums to the leading men of the track laying gangs, headmen of the packing gangs, or those acting as such when carrying out very important work, and to whom the control of large gangs amounting sometimes to as many as 50 men is confided, and who have to see that the work is properly done, that the output of the men is satisfactory, that the material is properly used, and that the working of the trains is not impeded :

3 to 6 fr. per day according to the importance of the work and of the results obtained.

Quarterly premiums of 60 or 50 fr., to the permanent way foremen who distinguish themselves by their keenness and devotion to duty with possible reduction if the work is badly done.

### Main French Railways.

By applying the statutary arrangements enforced on all the Railways, annual premium of 165 to 490 fr. to the section gangers, labourers in the yard, engaged on certain work of special difficulty, or who have as a result of their ability been employed on ordinary running maintenance work needing specialized knowledge.

Annual premium of 165, 325 or 490 fr. to the leading or assistant sectional ganger, having special knowledge and controlling a mobile gang of section men or labourers permanently allotted to certain special works.

Monthly allocation to sectional or district heads, when their work becomes temporarily of unusual importance, and which if it were to be continued would result in the grade of the post being raised. This temporary allocation may be 1/12 of the difference between the maxima of the scales of pay, corresponding, one to the temporary importance of the post, and the other to its normal specification.

### Paris, Lyons & Mediterranean.

Special gratuities to men who by their personal action and especially by the supervision they exercise when carrying out new work, result in shortening the time originally fixed for completing the work.

### Est.

Gratuities for good output in repair work based upon the number of metres repaired over and above the minimum fixed by the head of the section.

If the base length has been exactly done, each workman receives a premium of 0.65 fr. per day.

Increase or reduction of 0.13 fr. per 100th done above or less with a maximum of 1.30 fr. and a minimum of 0 fr.

*Premiums for activity when carrying out certain work in the stores and workshops of the fixed plant Department.*

Individual premium, or premium per gang is proportional to the time saved. The time allowed is equal to 15/11ths of the standard measured time. This premium is applied to such work as handling materials, sorting and classifying it, repairing and handling permanent way equipment, straightening and tarring coach-screws, repairing bolts, drilling and cutting rails.

*Task work in the creosoting plant.*

The staff is paid in accordance with the series of piece prices.

The pay is about 100/160ths of the legal pay.

### Société des Transports en Commun de la Région parisienne.

Premium for savings effected granted to the labourers dealing with permanent way work, and being a function of the difference between the time allowed and that actually taken.

The premium is distributed in relation to the time at work and to the base salary.

### Tunisian Railway Company.

Premiums of 20 to 50 fr. to men who particularly distinguish themselves in looking after and extending the plantations.

Special gratuities to supervisory staff who distinguish themselves by their zeal and devotion when carrying out repairs to the line as a result of storms.

# CHAPTER V.

## Temporary staff or contractors employed by the Railways for works of any kind : maintenance, cleaning, disinfection, repairs to rolling stock, fixed plant, buildings, or the line, office work, etc.

### A. — Temporary staffs.

#### Main French Railways.

As a general rule, the additional staff attached to a gang of regular employees, receives the same output premium as the latter.
In other cases, the output is not taken into account when determining their pay.

### B. — Contractors.

#### French State Railways.

The contractor for off-loading fuel from ships, penalties or premiums for hours lost or gained during off loading.

In principle, the value of the hourly premium is half the rates provided for as penalties.

#### Paris-Orleans Railway.

1. *Disinfection of wagons.*

The disinfection of wagons used to carry cattle, is undertaken by a contractor, who recruits any additional staff required.

The contracts entered into with these contractors, provide a fixed sum per wagon disinfected, taking into account the area of the vehicle. This sum varies with the locality.

Penalties are also provided for delays in carrying out the work.

2. *Repairs to carriages and wagons.*

The Railway hands over the repairs of its carriages and wagons to private companies.

The material required for the repairs, being, as a rule, supplied by the Railway, the role of these contractors is reduced to supplying the labour needed.

Each repair before being taken into hand is gone into and an inventory prepared, in which is stated the different operations to be carried out, and by means of a list the total time T allowed to the contractor is calculated for the repairs. It is then only necessary to multiply this time by an average rate of pay S taking into account the general charges in order to arrive at the price due to the contractor :

$$P = T \times S$$

This method of pay is nothing more nor less than piece work.

# CHAPTER VI.

## SPECIAL CASES.

### SECTION No. 1.

### Premiums and gratuities for good output which do not come under the classes shown above or which affect men not considered in chapters I to XII.

**Belgian National Railway Company.**

Premiums granted to supervisors over coal stacks and to oil issuers :

0.02 fr. per ton of coal issued;

0.01 fr. per kilogramme of lubricating material issued;

with a retention of 10 % for a deficit of 1 to 2 %;
with a retention of 20 % for a deficit of 1 to 3 %;
with a retention of 50 % for a deficit of 1 to 4 %;
with a retention of 70 % for a deficit of 4 to 5 %;
with a retention of 100 % for a deficit above 5 %
(when drawing up the monthly balance of coal or of lubricating materials).

Distance premiums granted to brakesmen :

0.10 fr. for each kilometre travelled beyond a minimum daily distance calculated for each depot based upon the distance worked in December 1925.

$$\frac{\text{Actual distance travelled by the number of men at work} \times 0.75 \times \text{number of possible working days}}{\text{the staff authorised.}}$$

The payment to the leading brakesmen, and to the chargehands over the brakesmen, is respectively 3 fr. and 1.50 fr. per 1 000 km. travelled beyond the minimum fixed for the whole of the staff under their control.

*Monthly premium for fuel economised at boilers and stationary engines.*

15 % of the price per ton of standard coal per ton saved.

*Monthly premium for petrol saved by the chauffeurs.*

The motor chauffeurs receive a part of the difference between the monthly petrol allowance and the actual consumption of the vehicle they have driven during the month. This part varies according to the ratio of the number of kilometres run with the same allowance during the month and the total monthly distance.

*Premiums for men engaged on motor repairs.*

The allowance in hours of work for the upkeep of the motors is fixed per 100 km. travelled during the month. The time saved is rewarded by a premium proportional to the hours on duty multiplied by:

1 for the labourers,
1.5 for the tradesmen,

2 for the leading hands and garage foremen,

2.5 for the man in charge of the garage.

*Premiums granted to the staff engaged in putting up electrical installations.*

Premium based upon the saving of time realized when carrying out the various works and proportional to the hourly pay of the men.

The premium of the supervisor and of the electrical engineer, is calculated at the rate of 0.88 fr. and 0.32 fr. per hour of time saved by the workmen under their control.

### Paris-Orleans.

*Premiums for savings granted to men in the electrical stations and subtations.*

a) *Firemen and drivers in electrical generating stations.* — The premium for supervision fixed by the agreement, varies with the savings in coal and oil according to the formula :

$P'$ Premium allocated =

$P$ Theoretical premium $\left(a\frac{C-c}{C}+b\frac{H-h}{H}\right)$

$C$ and $H$ represent the quantities of coal and oil allowed;

$c$ and $h$ represent the quantities of coal and oil used;

$a$ and $b$ are coefficients varying with the man according as the post occupied affects the one or the other factor.

b) *Electricians in charge of transformer stations.* — The statutary premium for supervision varies with the formula :

$$P' = P + P\ (P - 72) \times 0.0715.$$

$P$ being the quotient of the number of kw.-h. supplied by the station to that of the kw.-h. received.

*Competition for the welders.*

In order to keep the autogenous welders or electric welders up to the highest possible professional standard, these men are given 2 competitive tests, the first, which has to be passed by all the welders, the second which is only passed by those who have obtained the best marks during the first test (about 1/4 of the candidates).

Gratuities of 50 to 400 fr., are granted according to the marks obtained and the man classed first in the second test, receives a total gratuity of 600 fr.

### Alsace-Lorraine Railways.

*Allowance for unhealthy and dirty work.*

0.35 fr. per hour (minimum time spent : 1 hour).

*Allowance for work under ground.*

0.25 fr. per hour for tunnel of 200 to 799 m. (656 to 2 620 feet);

0.50 fr. per hour for tunnel of 800 m. and above.

### State.

Allowance of 0.625 fr. granted per parcel found, to men in the Lost Property Section (Enquiries Sections).

Allowance of 1 fr. for the welder engaged on welding copper firebox plate.

Allowance 0.50 fr. for the assistant welder.

(Per 1 000 km. (621 miles) worked by the engine repaired under the condition that this distance is at least 25 000 km. (15 535 miles.)

### Société des Transports en Commun de la Région Parisienne.

*General premium for work done in reducing the staff.*

In the departments or offices, where there is no efficiency task premium, the standard staff is determined each year on the first of January.

Each quarter, a calculation is made of the saving effected according to the following formula :

$E = (N\,j - N'\,j)\,t$, in which :

N represents the number of clerks in the offices shown in the standard establishment,

$j$ the number of days in the quarter considered,

$N'\,j$, the number of days the office staff are actually paid,

$t$ the mean daily pay.

Each department receives 30 % of these savings, and also 15 % of the saving realized for the whole of the departments is distributed between them taking into account the influence they have one upon the other.

The distribution between the men of the same department is done by reason of the days of work and on a figure fixed by the heads of the departments, with, in addition a coefficient of 1.25, 1.5 and 2, for the administrative secretaries, accounts secretaries, assistant chief clerks and chief clerks.

### *Premiums in case of accidents.*

Monthly premiums awarded to each driver who has not had any accident during the month, on condition that he has not more than six days off duty, during the month considered.

In addition a quarterly premium equal to one third of the total of the three last monthly premiums granted, is awarded, under certain conditions, to any man who has not had any accident during three consecutive months.

An additional premium equal to the quarterly premium, is awarded in addition, to every man who has received two consecutive quarterly premiums.

## SECTION No. 2.

## **Benefits other than premiums and gratuities for efficiency.**

None other than seniority bonuses, exceptional mention on the promotion list, citation in the general working notice or departmental notice, in force on the main French Railway Systems (see chapter I, section 1).

# SECOND PART.

## CHAPTER VII.

## MEASURES IN USE TO INTEREST THE STAFF IN THE GENERAL FINANCIAL RESULTS OF THE UNDERTAKING.

Among the steps taken to interest the staff in the general financial results of the undertaking, four Companies may be mentioned : The Paris-Orleans Company, the Belgian National Railway Company, the Northern Light Railways Company, and the Franco-Ethiopian Railway (Djibouti to Addis-Abeba), which have, at different periods, interested directly, in various ways, their staff in the profits of the undertaking. In addition, as from 1921, the main French Railways have also allocated to their staff, a management premium varying according to the general efficiency of the Railways.

### Paris-Orleans.

The example of the Paris-Orleans was reported and discussed at the 1890 Congress. The following is the way the question is presented in the Note published by the Paris-Orleans Railway upon the institutions founded by this Company for the benefits of its staff :

One of the first to do so in France, the Orleans Company has applied the system of participation in the profits.

Immediately after receiving his concession, Mr. Bartholoni, the President, took steps to associate in the success and the prosperity of the undertaking, the Officers and men of all classes who lent him their assistance. He therefore proposed to the Board of Directors, that the men should share in the profits of the Company as soon as these profits exceeded a sum sufficient to remunerate in a definite proportion the capital involved. This proposition was approved by the Board of Directors, and confirmed by the shareholders at the General Meeting on the 30 March 1844. The general economy of this measure, was summed up in the following fashion by Mr. Bartholoni: « To interest in the success of the Company, all those who, no matter in what way, are attached to its service, work for it, and contribute to its prosperity. This is at once to stimulate the zeal, reward the work, improve the status of the employees both in their own eyes and those of the Public, to attract and to hold men of capacity; and on the other hand, to create guarantees for the Company, finally to tend constantly to increase the products, and to reduce the costs : all these are excellent things, and from which the Company itself will reap directly or indirectly, the fruits. From another point of view, it is not right that men who give their life to the service of the Company, should be liable to fall one day, into neglect and need. The dignity of a great Company always suffers by the humiliation to which those who have had the honour to enjoy its confidence and to exercise some part of its authority, may be reduced. The measure proposed would result in avoiding any such eventuality, and would make provision against it in a permanent and regular manner, as it should be in the case of a properly regulated undertaking. »

Article 54 of the Bye Laws of the Company regulates the amount of the monies so set aside in the following way :

In addition to the various amounts of money specified in the previous article, (it was a question of the monies set-aside, for reserves, and to cover interest and amortisation of the share capital) and those to which the application of the relative agreement entered into for the guarantee of the interest by the State, and to the eventual share with the State of a part of the benefits, the nett earnings on the undertaking shall be each year, distributed between the shares, in the proportion of 1/600 000th per share, except as regards any new shares. Moreover when to the whole of the shares as interest and dividend a sum of twenty millions has been distributed, from the surplus of the earnings, there shall be taken 15 % which shall be distributed by the Board between the employees of the Company, in proportion to the rates of pay, or the services according to the bases laid down by the General Meeting of the Company.

When as a result of applying the above arrangement there has been distributed to the whole of the shares a total sum of 29 millions, the amount to be taken from the nett balance, shall be reduced to 10 %. When, as the result of applying the above arrangement, a total sum of 32 millions has been distributed to the share holders, the amount to be taken from the nett earnings, in excess, is reduced to 5 %.

The many improvements introduced in turn in this system has converted it into a real Pension Fund, which without any contribution of the parties concerned, has made it possible for the Company to look after its own employees, up to the period when the Law of 1909 laid down the Pension conditions for the Staff on the Railways.

Men joining the Company subsequent to the 1 January 1911, are obliged to join the legal organisation; those who were in the service at this date, can either make the choice of the new service or of the old organisation instituted by the Company; most of them, considered this organisation has many advantages above those granted by the new law and have asked to remain under the old scheme.

The alteration in the pension as a result of the 1909 law, resulted in alterations in the participation in the earnings. As a result of the regulation of 1912. the share of the men in the old pension scheme is as in the past paid when settling their pension; that due to the men in the new scheme is paid them in money.

None the less in the case of the latter men participation in the profits is considered, subsequent to the application of the new Staff Agreement, on the whole of the great French Railways, as the first factor in the annual gratuity that this law includes and which is incorporated therein, it being understood that, when this gratuity is less than the amount of the participation in the receipts, the difference shall be covered by a supplementary payment to the man concerned.

### Belgian National Railway Company.

In accordance with the arrangement of article 40 of the Statutes, the Belgian National Railway Company distributes amonsgt the staff, 5 % of the nett earnings of each year.

The first distribution was made in

1928, and covered the working period of 16 months (4 months of 1926, and 12 mounths of 1927). It corresponds to about 3 % of the pay as salaries which has been paid to the staff. The formula applied is the following:

### *Staff benefiting.*

All men in the permanent staff recruited not later than the 1 January 1926, excluding temporary or additional staff.

### *Value of the gratuity.*

A. — Officials and clerical staff: the most deserving men receive the standard gratuity; those of average value, the minimum gratuity; men of least merit, not receiving anything.

B. — Workmen: The men who have not received during the year more than 3 reprimands, receive the standard gratuity; the minimum gratuity is granted to those men who have received a severe reprimand, or more than 3 ordinary reprimands.

C. — Staff as a whole: No gratuity is paid to those men who have been severely punished during the period in question.

The amount of the gratuities depends upon the duration of the actual work, carried out during the period concerned : a reduction of about 10 % is made for each month of absence.

## Northern Light Railways.

At the end of the year, between the heads of Deparments, and heads of gangs, a sum corresponding to 1 % of the profits is distributed. The distribution is made in prorata to the salary or pay, taking into account the devotion and zeal shown by each man in carrying out his duties.

## The Franco-Ethiopian Railway (Djibouti to Addis-Abeba).

### *Staff in Africa.*

The special allocation is based upon the actual profits of the year in question, and calculated as :

10 % on the first million of this earning, and

5 % on the surplus.

The distribution is made between the men to whom it is granted, according to the number of actual days of work during the said period and in proportion to their fixed rate of pay, excluding all premiums, indemnities, allowances, subscriptions, or gratuities.

However, rates of pay between 12 000 francs excluded, and 24 000 francs included only enter into account for 50 % and the section above 24 000 francs, for 25 %.

### *Staff in Paris.*

Special allowance is calculated as 1 000 francs per franc of supplementary dividend distributed for the year in question in addition to the guaranteed interest of 3 1/2 %.

The distribution of this is made as follows:

I. — 45 % amongst the whole of the staff, in prorata to the time on duty during this period.

II. — 20 % among the staff in the offices in proportion to the time on duty.

III. — 20 % between the men whose pay is above 9 000 francs.

IV. — 15 % between the heads of the services.

The other measures taken by various Administrations with a view to interesting their staff in the general financial results of the undertaking, can be considered as forms of premiums for efficiency. The management premium instituted by the agreement of the 28 June 1921 on the new regime of the main French Railways may be considered as coming into this category.

As from the 1 January 1921, the retrospective date of application of this agreement, the staff of the

**Main French Railways**

benefit, like the shareholders, by a management premium which is a function of the growth of the traffic and of the saving in the operating expenses realised.

*Factors entering into the premium* : This premium is composed of two distinct elements which are also used to calculate the premium due to the shareholders :

*a*) 3 % of the excess of receipts for the year's working considered in relation to that of 1920 (increase in rates not taken into account). When the excess exceeds 20 % of the 1920 receipts, the figure applicable to surplus, shall be reduced to 2 %.

*b*) 1 % of the reduction in relation to the year 1920, due to the shortage of receipts compared with the expenses, or, if the receipts exceed the expenses, 1 % of the total of the excess and the deficit from 1920 (1).

*Calculation of the amount of the premium :* In order to ascertain the amount of premium due to the staff, the two factors *a*) and *b*) above, are doubled. If the doubled figure exceeds 1.5 % of the receipt for the year considered, the premium continues to increase by the addition of the surplus of the two factors not doubled.

Furthermore, unlike what takes place wich regard to the premium for the latter that due to the staff, is always paid as a whole to the men whatever may be the value of its total, and whatever may be the financial results of the year, whether it finishes at a loss, or a profit in relation to the year 1920.

Moreover, the premium paid to the shareholders may, on the other hand, be penalised to the extent of 2 % if there is a growth in the deficit for the year considered in regard to the year 1920.

On the other hand, if this premium exceeds a determined maximum the surplus has to be paid to the common funds, either as a whole or in part.

*Distribution of the premiums due to the staff.* — A public Decree dated the 28 September 1922 laid down the rules according to which premiums due to the staff are distributed.

According to the terms of this decree :

1. a quarter of the premium is distributed uniformly between the whole of the men who have received a gratuity during the corresponding year's work. However, the staff whose service is broken, only receives half that allotted to the other men;

2. the surplus of the part of the premium due to the staff is distributed between the permanent staff, with continuous or non-continuous service proportionally to the numbers obtained by multiplying the tenth of the merit figure by a coefficient varying from 0.5 to 18, according to the scale of pay in which the man in question is placed.

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(1) After the year following that in which the accounts will balance (that is to say when the receipts for the whole of the railways will at least equal all the outgoings authorized by article 15 of the convention) the premium will be increased by 1 % of the reduction of the debit or of the growth of the excess in relation to the year in which the accounts balance.

### Société des Transports en Commun de la Région Parisienne.

A special premium has been instituted in favour of the staff by the working agreement of the 20 September 1920 between the Société des Transports en Commun de la Région Parisienne and the Seine Department. This premium makes the staff interested in the development of the operating receipts.

With this object in view, 4 % of the receipts from passengers and publicity are granted to the staff of all grades in accordance with the following conditions:

85 % of the money set aside from the 4 % is distributed in prorata with the number of days of work between the whole of the staff except workmen not on the permanent staff exclusively engaged in building new lines;

15 % is also distributed in prorata with the days of work between the controllers, collectors and enginemen.

When calculating the distribution of this 15 %, each day is counted as one unit, and each controller and collector's day as two units.

### Sfax to Gafsa Railway.

The permanent staff receives a premium on the receipts as from 1926, as follows :

1.5 % of the receipts of the year;

90 % of this amount is distributed among the men prorata with their figure of merit for the end of the year, the number of days work done during the year, and a coefficient varying with the grade;

10 % goes to a mutual aid fund which makes it possible to assist men at work or retired, who, momentarily, find themselves in a situation in which they require assistance.

## CONCLUSIONS.

The above investigation that we have carried out on all the branches of activity of Railway Companies, shows, that most of the Railways and their departments have systems of gratuities and of premiums which assure a more or less considerable additional remuneration to the staff.

The conclusions which this investigation has brought out appeared to us capable of being summed up in the following way :

1. The growth in the institution of gratuities or of premiums, in order to obtain greater efficiency, shows the interest the Railways have taken in this system.

It is evident in fact, that the gratuities or premiums, result in the zeal and activities of the staff being stimulated to a greater extent and in a better way, than can be realised by the normal remuneration, which can not be exactly proportioned to the efforts and daily output of each man.

2. The necessity for defining the amount of a premium to be granted by formulæ which make it possible to proportion the amount of the supplementary allowances closely to the increase in the efficiency, has been recognised.

As a result, it has been necessary to accurately define the output required at the same time as the corresponding value of the premiums.

In order to arrive at this, several methods are in use.

In some cases it has been thought sufficient to codify the methods in use and to fix the figure for the production according to the results that these methods make it possible to attain.

Certain undertakings have endeavoured to arrive at greater accuracy when fixing the production rates after which a premium is due, and have not been satisfied to adopt the methods of working confirmed by custom. They have carried out a systematic investigation into the processes giving the greatest efficiency. They have in this way been automatically led to take into consideration the question of the scientific organisation of work, and to recognise that their studies should, to be logic, proceed — as we have pointed out in our precis — that of the premiums for efficiency.

Although the questions of rationalisation are outside the scope of the present report, we think it useful to briefly indicate the processus of the operations to which the Railways who have taken into hand this investigation, have been led :

*a*) Setting up of an industrial accounts office to ascertain the indirect charges.

*b*) Modification of the establishment by a carefully thought out specialisation of the management staff.

*c*) Detailed investigations into each operation in a unit of production so as to find without taking into account previous practices, the methods leading to the greatest output and to the lowest cost price.

*d*) Exact definition of the condition of work in each particular case, so that the methods, tools, speed, etc.... of each operation, shall be completely defined.

*e*) Investigation into the time to be allowed for each of these operations, taking into account the precise conditions laid down as above.

*f*) *After completion of the preceding investigations and with the certitude that the results to which they have led cannot be surpassed by improvements which are in the control of the management*, introduction of output premiums.

It is obvious that these stages are more easy to follow rigorously when organising repair work than when dealing with traffic operations. We think, however, that this presents a logical staging of the work of rationalisation and that there is every interest in following it up as closely as possible.

In any case, and no matter what method be employed when instituting these premiums, it is only equitable that any improvement in the output recorded after their institution, should result in the staff concerned being given an increase of pay proportional to the saving made by the shop using it as a result of the additional effort of the staff.

3. The enumeration, though incomplete, of the formulae in use given in the above report, show that the premiums and the gratuities are most variable in their objects, in their rates, and in the way they are applied. In our opinion, there does not appear to be any reason to endeavour, in order to satisfy an excessive desire for uniformity, to suppress the differences necessitated by the varied organisations, the multiplicity and variety of needs, the relatively very different importance of the same factor on the various Railways.

4. None the less, it is desirable that as far as possible, the formula which governs the award of gratuities and premiums for output, should be simple, and understandable by every one.

5. In order to avoid arriving at results opposite to those sought it is advisable that the recompense should be carefully graduated in any one place of work according to the difficulty of the work done by each man and according to the

output given, so that each man can readily see that every exceptional output results in an exceptional increase in his pay.

6. It is also desirable, in every case in which the useful effects of the work done by each man can be measured and in all cases in which the individual output can be measured, that the premium should be given a personal and individual character.

7. It has been observed, moreover, that one of the factors in the efficacy of the exceptional gratuities and of the output premiums, is the speed with which they are paid, or at least with which they are published, in the shop itself, the output recorded, and the amount of the premium granted for this output.

8. Seeing that an improvement in the output results in an increase in pay, it is certain and logical that any reduction in output, or wastage of time, tools, or materials, should be punished by a reduction, or even by the suppression of the premium or of the gratuity.

It is not always possible to bring home to the man concerned the consequences of his mistakes and bad practices, but each time that this can be done, it is desirable to determine who is responsible, and to give to the amount withheld — as to the premium itself — a personal and individual character.

In the same way as for the premium itself, the speed with which the reductions or suppressions of premium are made is a very appreciable factor in their efficacy.

9. As regards the management staff, it is desirable that the gratuity or premium should be based upon the whole of the factors which affect the output of the shop or of the gang controlled, and even, if possible, upon the immediate and subsequent consequences of the work of the shop or gang. It is desirable moreover that the premium or gratuity should be proportional to the personal influence exercised by the member of the management or directing staff.

10. As regards the participation of the staff in the general results of the undertaking, it can only be paid to the men concerned after the end of each year. The men cannot therefore when they give an additional output realise the supplementary gain that will be paid to them; the encouragement that any such participation can give psychologically varies therefore with the training and the intellectual qualities of the staff affected.

Experience shows that the greatest effect is exercised upon the management staff. It is consequently to this class of staff that it should be more specially be applied.

656 .1 & 656. 2 ]

# REPORT No. 2

## (Belgium, France, Italy, Portugal, Spain and their Colonies)

## ON THE QUESTION OF COMPETITION OF ROAD TRANSPORT (SUBJECT XIII FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1) (2),

By Mr. LE BESNERAIS,
CHIEF ENGINEER, HEADQUARTERS OF THE OPERATING DEPARTMENT, NORD RAILWAY COMPANY (FRANCE),

and Mr. DEGARDIN,
CHIEF ENGINEER, ASSISTANT TO THE HEAD OF THE OPERATING DEPARTMENT, PARIS-ORLEANS RAILWAY.

Figs 1 to 8, p. 2646 to 2652.

We have been given the charge of drawing up a report for France, Belgium, Spain, Portugal and Italy, their Colonies and Protectorates, on Question XIII as submitted to the Madrid session of the Railway Congress. The question reads as follows :

> « **Competition of road motor transport.**
>
> Effect of road competition on goods and passenger traffic and the best methods of meeting such competition both as regards the main lines and the branches. »

To enable us to make the required report we sent a questionnaire to all the members of the Association in the above mentioned countries.

For the interesting and detailed answers received from the greater number of the Administrations we wish to express our thanks; their considerable length however makes it impossible to reproduce them in full; we therefore propose to summarise them, keeping to the order of the questionnaire.

As the replies from the chief Italian Administrations had not been received when we drew up the present report, we intend to add them as a supplementary report see page 2653.

* * *

§ 1. — *Of what importance is motor traffic in the country to which belongs the area served by your railway? How great has been the development of this traffic during the last few years?*

*Please state if there are any official statistics on this subject, and from these statistics or any other means of information at your disposal state the number of vehicles in circulation, if possible for each year since 1920. Please distinguish the following classes of vehicles :*

a) *those intended for the transport of goods;*

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(1) This question runs as follows : « Competition of road transport. Effect of road competition on goods and passenger traffic and the best methods of meeting such competition both as regards the main lines and the branches. »

(2) Translated from the French.

b) *those used for passenger transport, and in this latter class : 1. buses and charabancs; 2. small vehicles (not more than 6 seats). Differentiate between private vehicles and those of the public town services.*

*Please give any other information which would make it possible to appreciate the distances covered by the above vehicles, such as the annual amount of petrol or similar combustibles used during these same years by these vehicles.*

Owing to the lack of detailed statistics on this matter the greater number of the railway companies consulted were not able to furnish us with such complete information as we could have desired.

We have summarised the information received, such as it is, in the table given in Appendix I. Its incompleteness makes it impossible to draw any precise conclusions from it or to establish a detailed comparison between the different Administrations or the different countries (1). However the rapid development of motor traffic is none the less obvious; in France and Belgium, for example, it can be seen that the number of vehicles licensed for passenger transport has been more than trebled since 1921.

This alone would be a proof, were one needed, that the motor transport question does exist; it remains to be seen in what measure this transport is deleterious to the railway or whether it could become of either direct or indirect assistance.

* * *

§ 2. — *What areas are covered by the regular motor services, whether bus or lorry, in the region served by your railway, and what has been their development during these last few years?*

*Please give the number and length in kilometres of the regular motor routes near your railway which could have any influence on its traffic.*

*Tabulate if possible this information for each year since 1920.*

The table given in Appendix II is a summary of the replies received which were however often incomplete. It clearly shows that the regular motor services, which are liable to compete with the railways, because carrying out the same public transport services of both goods and passengers, have greatly developed and are rapidly growing. Their mileage also is impressive if compared with that of the railways; in Belgium it is 1/2, in France 3 times as great (if only the 7 great railway companies are taken into consideration), in Portugal (in the neighbourhood of the Portuguese Railways) 10 times as great. At the same time the importance of the traffic is far from being in proportion to the distances covered, and as we shall see, a great number of the routes tend to increase the railway's traffic rather than to compete with it.

* * *

§ 3. — *What proportion of the total mileage given in paragraph 2 is covered by regular motor services between places already joined by the railway, these motor services being more or less parallel to the railway and therefore liable to compete with it?*

*Indicate if possible the annual differences in services of this kind since 1920.*

The table given in Appendix III drawn up by means of the replies received to this question show that the number of such services is far from being negligeable. Among the existing motor services the proportion that compete with the railway varies considerably in different regions. As far as main lines are concerned this proportion falls to about 10 % in thinly populated areas where the stations are far apart, but it is more than 80 % in the highly populated industrial and commercial regions. In the case of the small local railways and certain branch lines of the large railway companies. it is quite another matter; there is often direct competition under conditions very favorable to the motor.

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(1) This same observation also applies to the different tables of statistics drawn up in support of this report.

⁂

§ 4. — *What is the passenger and goods traffic of the competing motor services mentioned in paragraph 3, and how much has this traffic increased during recent years?*

*Please state for 1927 and as far as possible for every year since 1920 the number of buses and motor lorries (each class of vehicle separately) which have run regularly on these routes, the number of passengers and tons of goods carried yearly as well as the number of passenger-kilometres and tonne-kilometres.*

By means of this question we were enabled to draw up the table given in Appendix IV which completes the information summarised in the preceding tables.

The figures in the last colums are wherever possible shown in comparison with those of the railway traffic as far as we were able to ascertain this from the latest tables published by the U. I. C. (International Railway Union). This shows that even if a regular competitive motor service exists it is very far from being completely victorious; it is however to be feared that motor transport will take the pick of the traffic as the regulations imposed on it are much less strict than in the case of the railways who are obliged to accept every kind of traffic no matter how unremunerative it may be, while the motor services need only be set up where the competition is easy and paying.

Also, as above, in the case of the small lines who cover very much the same areas as the motor services, the ratio between the traffic of the two services is often in the favour of the road.

Furthermore it must be noticed that in France, for example, this competition is fairly recent; in fact it has only really developed since 1925 or 1926 for causes which we will consider further on.

⁂

§ 5. — *What regulations are imposed in your country in the case of the regular motor services?*

*Please indicate the conditions demanded by the public bodies (State, departments or provinces, towns, etc.) of the companies organising and working regular motor services and especially:*

a) *Are the regular motor services necessarily the object of concessions or licenses which need administrative intervention? If this is so give the division of the lines dealt with under both paragraph 2 and paragraph 3 as between lines entirely free, and lines simply subjected to the obtaining of formal authorisation without any other participation of the public authorities as to clearly defined obligations concerning the extent of the service and the financial intervention of the said authorities.*

b) *Are the regular lines of motor services having a concession part of a general plan that has in view the best pos-*

*sible method of meeting the needs of the country or is the concession-holder free to decide upon their direction?*

c) *Are the concession-holders of regular motor services subsidised by the public authorities? What are the public bodies that bear the weight of these subsidies? How are they decided upon, divided, and assigned?*

d) *Do the regular motor services, whether free, authorised, or the object of a concession, bear a part of the construction and upkeep expenses of the roads used by them? If so how much and in what way? What taxes are imposed on them? Compare these expenses and taxes with those borne by rail transport.*

e) *Are the rates of regular motor services, whether free, authorised or the object of a concession, submitted to the approval of the public authorities? (which?) or simply decided by the concession-holders?*

f( *Are the concessions of regular motor services monopolies for the working of those routes or is there open competition either between themselves or with such regular services as are not the object of a concession (free or simply authorised)?*

g) *Are there any enterprises (State enterprises, those of communes, etc., or those of certain railway companies) which enjoy a preference in the obtaining of concessions of regular motor services?*

Conditions differ considerably from one country to another.

In general the public transport services must have a preliminary authorisation from the competent authorities (Belgium, Law of 15 September 1924; Spain, Royal Decrees of 4 July and 11 December 1924; France, Decree of 31 December 1922).

In Belgium the creation of regular passenger services depends on the approval of the King after an enquiry has been made into the utility of the enterprise, the proposed route and the rates. The principle of a compensatory indemnity has been considered in the case of these services when there is competition, and it has sometimes been applied in favour of the National Railway Company. On the other hand no legal measure has been taken to prevent competition with the railways as far as the transport of goods is concerned. There is no general plan for the regular motor services; those who exploit such services do so as a rule without any subsidy from the public authorities except in an indirect fashion in the case of those services organised by the National Light Railway Company.

The rates are submitted for approval to the authorities who have given the necessary permission to start the service, but competition is in fact possible between the different services; the National Light Railway Company alone enjoys the preference in obtaining concessions of certain services in the following cases :

1. when the required services would work routes forming part of their projected lines;
2. when the route would follow that of their actual lines;
3. when it would join two points served by their lines.

In Spain, on the other hand, an effort to organise has been made; the road passenger transport services are under the control either of the Departmental Committee or of the Central Committee of Transport, according as to whether their sphere of action is limited to a single department or not. The concession is granted according to a Specification drawn up by the Committee if there is only one demand, or after having been competed for if there are several.

The Specification grants a monopoly for twenty years; in exchange the transport of the mail is free and a tax is paid towards the upkeep of the road.

The regulations enforced in the case of irregular services and in town or suburban services are less strict.

The concession-holders do not as a rule enjoy a subsidy; the taxes paid by them are much less than those imposed on the railways; the rates of regular conceded lines are submitted for approval but those of other lines are free.

In Portugal there are no proper official regulations but rather complete liberty and independence.

In France the motor services do not receive any grants; in order to work them it is only necessary to make a formal declaration to the Prefecture and to satisfy the usual safety regulaltions.

Many lines receive subsidies from the communes and departments, part of which are paid by the State if the service is not in competition with either other motor services already subsidised by it or the railways; in return the concession-holder must submit to a Specification regulating his obligations in the matter of rates, mail transport and timetable.

There is no preference shown in granting such subsidies. The rates of bus services other than those of subsidised services are free from control.

As far as the participation of the motor services in the construction and upkeep expenses of the roads used by them is concerned, the taxes imposed especially under the headings : roads, petrol, oil, are, as we shall see (§ 11) in most cases very far from equal to these upkeep expenses. There is also a great deal of unfairness as the taxes favour road transport to the detriment of the railway.

In Tunis the regular motor services are worked either under concession when they are subsidised by the State, or are simply authorised.

* * *

§ 6. — *What are the passenger rates and the goods rates of the regular competing motor services? Are there any fixed regulations to determine the amount of these rates? What ratio is there between these rates and those of the railway on corresponding routes ?*

*Please state the average and the maximum rates per km. in the current coin of the realm and in gold-centimes and the ratio in percentages to the corresponding railway rates. How have these rates and this ratio developed in recent years?*

The table given in Appendix V which summarises the replies received shows that there is no precise rate per km. for motors. As they are usually free from taxation this depends above all on the effects of competition. On the whole, however, it will be seen that for passengers the rates are on the average much the same as those of second class railway fares, (in Portugal however they are distinctly less) while as far as goods are concerned they are based on those of the railway but usually slighly less.

In France the Specifications of subsidised services usually arrange for fares to be about 0.25 to 0.30 fr. per km. (0.40 to 0.483 fr. per mile) while second class railway fares are 0.304 fr. (0.489 fr. per mile) (tax included), but except in rare cases there are no special rates for return tickets nor any such reductions as are given by the railways to many kinds of travellers.

* * *

§ 7. — *Can you observe any diminution of traffic on your railway directly attributable to the development of traffic on adjacent lines of regular motor services?*

*Please give as a percentage of the total traffic the probable diminution in the number of passengers and tons of goods for the whole distance and per km. of the distance on those sections of your railway where there is active competition.*

*How much has this loss increased during the last few years ?*

a) *Passengers.* — In general the railway companies have noticed a diminution in passenger traffic without however being able in every case to give the percentage of this diminution due to road competition. Because of the relatively small length of each of the regular routes at present this competition does not greatly affect main-line passenger traffic. It is also partly made up for by the fact that certain motor services act as feeders to the railway.

The situation seems to be particularly serious in the case of branch lines and small railways the place of which is being taken more and more by buses; the Northern Light Railway Company, for example, shows in comparison with 1913 a diminution in the number of passengers which reaches 20 to 30 % on its Pas-de-Calais lines, and as much as 53 % on those of the Isère; the Algerian lines on the Paris, Lyons & Mediterranean show a relative diminution of as much as 50 % for journeys of less than 50 km. (31 miles); the Smyrna-Cassaba Railway gives its loss as 14 % while the Portuguese Ministry of Colonies estimates the amount of passenger traffic lost by the Mormugao line as between 10 and 25 %.

It is to be feared that this competition will go on steadily progressing because of the creation of motor services for longer routes, and also because of the facilities enjoyed by the motor for choosing paying services and for catering only for the regular traffics, while at the same time it benefits from tax exemptions in connection with the upkeep of the roads.

b) *Goods.* — Here also the competition, whilst slight as regards tonnage in the case of the main lines, is much greater in the case of secondary lines.

The table given in Appendix IV gives the ratio of road and rail traffic for all the lines of each of four of the large French Railways, these Companies having no statistics which enable the diminution on the lines or parts of lines where there is competition, to be determined separately. In kilometric units this ratio varies from 0.02 to 0.08 %.

The branch lines are more affected; the Tarn Departmental Railways, for example, have suffered a loss of from 10 to 20 % of the traffic according to the route.

The Algerian Railways of the State show on their short distance routes, a very great loss which they estimate at 50 % for distances of less than 50 km. (31 miles), while the Réunion Railway shows a loss of respectively 23 % and 10 % on fast and slow goods traffic.

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§ 8. — *Besides the regular motor services considered in §§ 2 to 7 what is the importance of the passenger and goods transport carried out either by intermittent or irregular services, or by motors and lorries belonging to private individuals who use these either for their own needs only or also for their needs and on account of other people?*

*Indicate as in paragraph 7 the effects of this competition on the traffic of your railway.*

a) *Passengers.* — All the replies made to this question show that such competition exists but that it is impossible to estimate it at all precisely. It seems to be above all of importance as regards journeys made by private individuals themselves for these find in the use of a motor accessory advantages which a public service such as the railways is unable to offer them.

Several particular examples of the importance of this competition have been given us. For example, the French Nord Railway Company states that at the annual horse races at Chantilly the proportion of the total number of spectators who travelled by rail which, in 1923, was 84 %, has fallen through motor competition to :

79 % in 1924.
69 % in 1925.
68 % in 1926.
63 % in 1927.
65 % in 1928.

This competition seems to be of special importance in the case of small local lines; the figures given us by some of the large Railway Companies are only small, between 0.05 and 2 %; on the other hand companies such as Light Railways of the Nord (Isère system) and the Deux-Sèvres Tramways have suffered a loss of 15 to 25 % in passenger traffic, and the Gafsa Railway, a loss of 60 %.

b) *Goods.* — As far as goods are concerned many important elements necessary for a complete estimation of the position are lacking. We have to consider in fact a multitude of transports carried out for all manner of distances more or less regularly. In this catagory is included for example ;

1. Deliveries from the large stores round the large towns in which they are situated, and even in towns some distance away; these establishments are very fond of this kind of transport which has the additional advantage of giving a good advertisement at small cost.

2. Distribution between the depots and the branches.

3. The transport of goods from one factory to another for the undergoing of different processes and from the factory to the wholesale stores, and the carrying back of raw material.

4. The transport of commodities, farm and market garden produce, to the markets.

In the areas served by the Nord Railway, an evaluation of the transports carried out either regularly by private individuals or intermittently by public enterprises over distances of 20 km. (12.5 miles) or more, gives for 1927 a tonnage of 186 500 tons which represents 8 156 000 t.-km. (4 988 000 ton-miles), the ratio between this traffic and the tonnage carried by the railways being 0.31 %. It should be noted that the ratio of the traffic of regular motor services to the same traffic by rail is 0.34 %.

The Paris, Lyons & Mediterranean Railway Company has made the following comparison as regards the transport of flour and beer :

| | Tons of flour. | Tons of beer. |
|---|---|---|
| Tonnage transported by rail in 1927 . . . . . . . . | 269 650 | 43 104 |
| Tonnage transported by road in 1927 . . . . . . . . | 171 000 | 53 200 |

In Tunis, the loss occasioned to the railways by private motor services has been evaluated as follows :

20 to 30 % of the cereal traffic,
40 to 50 % of the wine traffic,
60 to 70 % of the oil traffic.

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§ 9. — *Independently of the rates, what inconveniences have been observed on your main and branch lines likely to cause passengers and consignors to make use of road rather than rail services ?*

*Please indicate the measures taken by your railway to acelerate transport, to make the services more frequent, etc.*

Since motor competition does exist and especially since it has outlived the first craze for the new, the question must be asked whether it has avoided certain faults inherent in rail transport, and whether any successful measures have been taken or could be taken to correct these faults.

a) *Passenger.* — In the opinion of certain companies (Spain, Portugal, the minor French and Belgian Railways) the motor has the advantage of being faster and more comfortable. The remedy would seem to lie in speeding up the trains and renewing old stock, measures which so far have been delayed from reasons of economy. But these Companies recognise that even if such measures were taken the railway would still have certain drawbacks attached to it : too few trains, stops not frequent enough (unless the time taken for the journey be greatly increased), the service given too closely limited to the actual railway track, the difficulty of increasing the daily extent of the service because of the high cost of supervision, costs corresponding to the superabundance of stock due to the obligation under which the railways lie of accepting all kinds of traffic no matter how irregular.

The general remedy of these inconveniences would indeed, so it seems to us, be difficult and expensive; the high cost of new trains, the difficulty of combining rapidity with frequent stops, the practical impossibility of making new lines which would be useful.

Without doubt the use of motor rail coaches is often a very useful solution, especially on minor lines where at the cost of making the rules less strict these vehicles enable new facilities to be offered to the public, such as the separation of the passenger and goods services which were formerly joined on a number of small lines, or the making of halts at certain level crossings as is the practice of the urban tramways and some of the local narrow gauge lines; but their efficiency is often limited by the impossibility of using them on other than morning and evening trains.

It would therefore seem that the best method in such cases would be to suppress the rail service more or less completely on such lines and replace it by a road service augmenting or prolonging the railway. In this way it would be possible by short distance services in thinly populated regions where there is but little passenger traffic to profit by the advantages of the new method of transport, advantages essentially consisting in the possibility of working in small units frequently and relatively quickly.

This new method of transport also commends itself when it is a question of serving regions or places at some distance from existing lines, or of making new lines to deal with tourist traffic that varies with the season, especially when account is taken of the excessive cost of making new lines in such regions which are usually mountainous.

On the other hand, the railway can easily beat the motor as far as speed is concerned and it is the best method of transport for those passengers who wish to undertake long journeys. It should therefore be able to maintain the advantage as far as the important and much frequented lines are concerned.

The question of competition thus gives place to the problem of the most advantageous use of the different methods of transport available and it seems to us that every effort should be made towards the establishment of a closer collaboration between the railway and the road services. To the share of the motor should fall those services where there is no need for any great frequency by means of which it is possible to multiply the services without an excessive increase in expenditure, those services which connect stations and outlying localities, new services in places where there is no railway, and lastly the tourist and excursion services which complete the railway. On the other hand the railway should keep the long distance services in which it gives additional speed, comfort and safety (¹), and all the important and frequent services which exceed the pratical possibilities of the motor. This distinction between the spheres of road and rail transport would thus leave to each the activities in which it can play the most useful and profitable part.

From the point of view of the tourist this utilisation of rail and road resources seems to suggest the following remarks. First of all the tourist general transport undertakings act as feeders and are complemental to and not in competition with the railway. The example of certain companies, at the head of which the French Paris, Lyons & Mediterranean may be mentioned, who have organised both directly and indirectly magnificent motor services for tourists, should certainly be followed on account of the business brought by such services to both the railways and the regions served by them. The security, the regularity, and the moderate prices arranged by the railway companies in those services over which they have control, qualities which similar services in competition with them are therefore also obliged to offer the public, are the principal reason for their success.

On the other hand the advantages of private motors are such that many tourists in order to benefit by this will take the trouble of driving all the way from their homes to their destination at the cost of much fatigue for but little extra comfort. The French Railway Companies thought it possible to take measures to reduce this loss of traffic by offering to the public a rapid transport of their motors at a special reduced rate. This measure gave appreciable results which might perhaps be still further increased by the creation of centres in places frequented by tourists where the transport resources are but poor, at which it would be possible to hire motors for the use of individuals or families, these services being so organised as to make it possible to assure passengers who place an order at the station on their departure that on arriving at their destination they will find a vehicle waiting for them, with or without a chauffeur, for a specified time or route.

b) *Goods.* — The replies received make it clear that if road competition chiefly concerns those goods for whose transport the railway is still too slow, it is still further increased by the fact that the

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(1) This aspect of the question usually escapes the public; statistics however show that the number of passengers killed or injured for the same kilometric distance is considerably higher in the case of motors than it is on the railway: 50 times as many in France per passenger-kilometre.

railway often requires the consignor to use packings that are not only expensive but take a long time to prepare while at the same time the customer has all the trouble of taking his goods to and from the station while there are complicated formalities to be complied with at each station.

As far as rapidity is concerned competition in the matter of speed is very strong and here again the motor enjoys many advantages. It is in general a question of goods that are not very heavy and are consigned in small quantities often better suited to the capacity of a motor lorry than that of a wagon. Besides this the higher rates of the railway give the motor services a larger margin for establishing theirs.

Finally the motor can more easily collect goods from those consignors and senders who are not on branch lines and at the most convenient times. The result is that less handling of the goods is required while the journey is often appreciably shortened. The motor is able to choose the paying transports while the railway must accept every kind and at fixed rates no matter who or what the customer or traffic, so that it is not able to offer lower rates to keep the custom it is loosing nor yet to make those customers to whom is it indispensable, pay to the full for the services they receive.

Here again the struggle may be maintained by reducing delays in transport, diminishing the conditions imposed on tonnage and extending the times at which the stations are open. But the difficulty is greater or less according to whether the railway has to compete with public or private services.

The railway is but poorly equipped to fight against those public services which assure especially the transport of details; it has however at its disposal a precious auxiliary in the person of the « cartage agent » who collects and delivers the goods which the railway will carry in bulk from one station to another under the best conditions for insuring speed and cheapness. The role of this auxiliary could, we think, be considerably developed by directing it in such a way as would enable the public to dispense with many of the formalities required in sending goods, simplify and in some cases do away with packing altogether and above all conduce to the real unity of the door to door transport system by getting rid of the trouble of carting and the routine proceedings in the stations, and it would also accelerate the payment of charges and the return of empties. Here again it is really a question of the collaboration of the railways with road enterprises which would undertake the commercial relations with customers like the road transport companies. These enterprises could be either collectors in the literal sense of the word, or local correspondents, or even those affiliated companies of which we will speak further on, provided that such companies know how to retain that pliability in their relations with the public and in their technical and commercial organisation upon which their place depends and which is the strength of the free motor services.

As far as private services are concerned the advertisement given to many firms by the use of their own motors is a strong inducement against the use of the railway. It must be recognised that the struggle is often a practically impossible one when it is a question of regular transports which assure that a motor will have a round of from 200 to 350 km. (142 to 217 miles) practically every day, rounds which can be economically done with one or two drivers. But in most cases the railway still has the advantage when it is a question of less regular transports of a greater tonnage or for distances that are too small economically and technically too great. The multiplicity of its workings make certain a reasonable average use of its stock; the arrangements of the traffic make it possible to make up heavy trains for which the cost per ton per km. is noticeably less than in the case of a single large lorry. It can also deal with transports for the greatest as well as the smallest distances.

In order to maintain the struggle successfully the railway should always follow the efforts made by the motor services, especially as regards the facilities and satisfaction to be given the public. When it is a question of delay, of conditions imposed upon tonnage, of exigencies as regards packing or claiming goods, or the taxes to be received, it is essentially by means of modifying its rates that it will succeed, and we intend to make this the subject of the following question. Here we will therefore only mention one particular solution of certain difficulties (packing, handling) with which we will deal more fully in paragraph 14, that is to say the use of containers which make possible door to door transport.

* * *

§ 10. — *What measures have been taken on your railway from the point of view of the rates to diminish motor competition?*

*Please state to what degree a revision of the rates on your lines might in your opinion diminish this competition and if this revision is compatible with the existing regulations for the establishment or the modification of the rates, or if it is not if it would be possible to make certain changes in these regulations and what these changes would be.*

a) *Passengers.* — The information furnished in paragraphs 6 and 7 shows that as far as passenger traffic is concerned motor competition is much less a question of the fares charged than of the conveniences offered of frequency, rapidity and the train times. It is therefore not suprising that there have not been any great efforts made to prevent such competition as far as the rates are concerned, especially when the difficulty of judging in what kinds of traffic there is fear of competition and the loss occasioned by any other than a merely local reduction in rates is considered; it must however be noted that in France the fear of motor competition was partly due to the fact that the passenger rates had been in general much less increased than the goods rates.

However this might be, the tariff reform measures that have been taken chiefly concern group journeys, week-end and Sunday return tickets, the granting of monthly season tickets between certain places, the reduction in price of ordinary season tickets, the introduction or extension of family tickets, excursion tickets, special tickets for watering places or seaside resorts, extended availability of return tickets, less strict regulations as regards breaking journeys, the rapid transport at a low rate of motors accompanying passengers, etc....

In general these different measures also apply to the whole of the railway and are not limited to certain parts where there is special competition; they are therefore as much, if not more, directed towards the development of the passenger traffic, in those cases where a reduction of the fares is capable of assisting this development, as against competitive services.

The rates can, nevertheless, reveal the collaboration which exists between the railway and those motor services which act as feeders or correspondents; especially as regards the facilities offered for through booking of tickets and luggage for mixed rail and road journeys; and in France this measure is applied particularly in the case of certain excursion tickets common to the railway and tourist motor services, and to certain bus tickets on the routes of the affiliated companies of the large Railways which are issued jointly with railway tickets, sometimes even reserving a place on the motor bus.

b) *Goods.* — The Belgian National Railway Company has tried to combat motor competition by granting special facilities for carrying goods consigned by different people in the same wagon, by speeding up the transport (especially in the case of mails and perishable commodities, accepting free of charge the ice accompanying certain commodities (butter, fruit, meat, fish, beer), by lowering the rates for the return transport of empties, by granting period rates for shuttle services, and lastly by carrying motor vehicles at reduced rates.

The French Railways have taken very much the same measures: premiums on tonnage and regularity, especially in the favour of collectors; fixed prices especially as regards the rates for the bulk transport of goods consigned by different people by both fast and slow goods trams; rates for door to door transport, etc....

The North of Spain Railway states that the delay in confirming the modifications in the rates and the necessity they are under of only making reductions of a general character applicable for at least a year, has prevented them from taking any action in this matter.

We note that the railway rates usually decide upon fares that are proportionnal to the weight carried and increase with the distance, less quickly than these however (Belgian tariffs) according to a classification table the basis of which is the value of the goods. The reductions, usually small, given to large weights are generally only granted to quantities too large to have any bearing upon motor competition where the weight carried does not as a rule exceed a few tons.

This system of rating usually ignores questions of distance and arrival, special conditions of dispatch and delivery, the existence of a competitive method of transport; it arranges for large delays which enable the service to be economically run by an appropriate grouping of the goods; it imposes strict conditions on identification and packing in consequence of legal measures which have constantly increased the responsibility of the railway. The very form of the decreasing rates and the application of terminal charges independently of distance gives a severe blow to transports over small and medium distances where competition has its maximum sphere of action. Above all it carries with it a strict application of the principle of equality of treatment and the legal obligation of the rates, the price no doubt of the monopoly once enjoyed by the railway, but now a definite drawback in face of a new competitive service to whom such a principle does not apply.

Such a situation leaves the railway at the mercy of the road transport services who are free to seek out only such kinds of transport as are regular and paying, able to adapt themselves to the hours and needs of a single customer or several selected customers, regulate their charges more or less independantly of the value of the goods especially in the case of those most highly rated by the railways, profit by their free choice of customers to reduce to a minimum the formalities and packing required by substituting a system of mutual confidence for the guarantees of the regulations, and promise only very short delays, a promise which is usually kept, but the breaking of which entails no obligation on their part.

The railway rates must therefore be made much more flexible if equality is to be established between rail and road competition. In the first place it must be made possible to enforce immediately any modifications that would seem useful. Whether it is a question of extending in certain cases the hours at which the station is open, or of lowering certain rates, the simplification of the preliminary formalities and their acceleration are absolutely necessary; without doubt, in France especially, serious efforts have been made in this direction (the authorisation to apply provisionally certain rates) while awaiting official sanction, but this is not sufficient and it is possible to conceive, at least in the case of the conditions under which transports are effected and even perhaps as regards the rates, that the measures already in force for export and transit will be extended so that the railways will be able to apply these after a very short time counted from submitting them to the Administration, and except when vetoed by the latter, after an appropriate publicity sufficing to prevent any arbitary measure being in the nature of a private favour.

The railway should also be able to give any of the measures taken against competition a provisional character so that there would be no difficulty in modifying or repealing them if they proved inadequate or ineffective; with this object in view a corrective should be applied to the regulations enforced at the present as regards the minimum time any new rate must hold good.

Finally it should be possible to limit the measures taken, which are always costly when it is a question of lowering the rates or extending the facilities offered to patrons, to those transports in which there is competition. Any obstacles in the way of such limitation prevents the railway from taking adequate measures of defence because of the loss it would occasion in the case of transports where there is no competition. The solution of fixed prices for definite relations and goods doubtless constitutes a first step in this direction, but it is still insufficient is the face of a competition for whom a private agreement is the rule and it would be necessary to better this both in the case of individuals and collectors, by granting more freely premium formulas to tonnage and regularity analogous to those allowed in France for the rates of complete trains loads which definititely constitute really advantageous agreements at a price which decreases with the tonnage. These formula should not, however, exclude alongside the prices clauses properly speaking, conditions of quick transport, the simplifications of the packing required, and of claiming the goods and the other formalities at the station or the private sidings at departure and arrival, the speedy return of the packings, the rapid payment of charges, etc., in such a way as to keep pace with motor competition as regards the facilities it offers its patrons.

All these measures enable the railway to fight on an equal footing wherever this is economically possible. To omit to apply such measures would be to bestow excessive privileges on the road services to the detriment of the railway, privileges which distort any comparison between the cost prices; under colour of maintaining the principle of equality and protecting the weak (the scattered motor enterprises) against the great railway companies which have long attained the perfected form of a great undertaking, this would encourage, at the expense of the country as a whole which supports the cost, the creation and maintenance of uneconomic transport artificially bolstered up.

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§ 11. — *To what causes other than those considered in paragraphs 9 and 10 do you attribute motor transport competition and what masures have you taken or in your opinion could you take to attenuate these causes ?*

*Please state the measures which you have taken or are considering taking to maintain the struggle against the competition of the regular motor services or of the free or private motor traffic, the degree of efficacy of these measures and the conditions necessary to augment this efficacy.*

Independently of the causes summarised in paragraphs 9 and 10 (faults inherent in the railway and faults due to their system of rates) the replies we received give three kinds of reasons for motor competition all of which have to do with financial considerations : *a*) subsidies; *b*) taxes; *c*) upkeep expenses.

a) *Subsidies.* — These subsidies are perfectly justified when it is a question of aiding an enterprise of general interest to be started or to carry on when its own receipts do not cover its expenses.

The railways themselves at their inception profited by subsidies of one kind or another : capital, land, labour, assurance of interest, etc.... It is right that motor services, started where they will supply a real need, should benefit by similar advantages.

But only too often these subsidies, especially when granted by the local authorities, have as their end not to make possible a new service but the facilitating of competition against a railway service already in existence; local complacency makes the advantages expected from the new service seem worth while, the locality having however to cover the deficit.

When this subsidy is too large and necessitates recourse to the intervention of the State, somewhat more serious guarantees are usually required; not enough however to avoid abuses.

b) *Taxes.* — The State, which has need of money to assure the general services it owes to the country and to keep pace with the charges of the national debt which is often a heavy one, taxes every available object not excepting transport.

It should, it would seem, lay an equal burden of taxation on the different methods of transport, but it does not.

In France, for example, the motor services do not pay any tax on passenger transport, while the large Railway Companies have to pay a tax of 32 1/2 % and as much as 65 % on supplements for luxury services; in the case of goods traffic they pay a tax of 10 %, though this is reduced to 5 % in the case of certain goods of very small value or for current consumption.

The result is that when a passenger buys a ticket for 10 fr. the motor service gets the lot where the railway only gets

7.55 fr., or again, to get a net receipt of 10 fr. the railway must collect 13.25 fr. from a passenger but the motor service only 10 fr.

No account need be taken of the taxes which apply specially to motors, petrol tax, circulating rights, etc., since as we shall see these are very much less than the value of the services the State renders them for nothing.

This difference in the taxes imposed on transport is therefore a supplementary charge imposed by the French State on its railways : in the case of passenger traffic in particular, it is so great, as the figures given above show, that this alone frequently enables the motor services to compete against the railway; the country as a whole loses moreover all the money it might raise by a reasonable tax on those transports that are not carried by the railways.

In Spain the situation is very similar. The motor transport services pay a tax of 0.10 peseta per km. (0.16 peseta per mile) or else a tax of 2 % on the figures obtained by multiplying the number of journeys by the number of seats and the price of each; the railway on the other hand pays a tax of 25 % for passengers (lowered to 15 or 10 % in the case of cheap tickets) and 5 % for goods, which is about 5 times more than the motor services have to pay.

c) *Maintenance expenses.* — Furthermore, not only does the railway receive no subsidy, not only does it have to pay higher taxes, but the motor services do not have to repay all the expenses incurred in enabling them to function.

The railway, the passengers who use it, the goods carried by it, all have to pay a large proportion of the cost of construction and all the expenses of maintaining the permanent way. The motor services have no construction costs and no upkeep expenses to pay or else only pay a small proportion of them.

For example, in Belgium, although there the principle of a royalty paid by the motor services as a participation in the road upkeep expenses if not adopted officially is however more or less generally applied, the royalty paid by the regular motor services is never more than 5 % of the gross receipts while the upkeep of the road alone without counting the capital expenses incurred in the first construction, absorbs more than 15 % of the receipts.

In Spain the specification lists of concession-holders arrange for the payment of a tax towards upkeep expenses which must be not less than 0.0025 peseta per tonne-kilometre (0.00394 peseta per English ton-mile) hauled, but evidently this is but a very small part of the upkeep expenses incurred, and in any case it is nothing compared with the construction costs which the railways have to pay in full.

In Portugal the average expenses borne by a motor vehicle of more than 12 horse power intended for the transport of passengers may be estimated as 375 gold-fr. while the railways pay a tax of 12 % of their gross transport receipts; to make the situation between the two services equal the gross receipts of the motor service must not exceed 3 125 gold-fr. per annum for each vehicle, or, allowing a distance of 100 km. (62 miles) for 300 days of the year, 0.10 gold-fr. per km. (0.16 gold-fr. per mile). Here again the weight of taxation borne by the motor services is much less than that by the railways, and, a fortiori, the motor is very far from paying for the upkeep expenses and still further for the construction costs of the roads it makes use of.

In France, the motor services do not pay any tax directly set aside for the construction and upkeep expenses of the roads; but they are liable to the fiscal taxes which cover a part of the moneys set apart for the roads. The total of these taxes can be estimated at about 1 600 million fr. (1) for 1927, while the upkeep expenses of the roads for the same year were of the order of 2 000 millions, expenses 9/10 of which, i. e. 1 800 millions may be estimated as the share of the motor services when their frequentation of the roads as compared with that of its other users is taken into consideration. To these expenses must also be added the capital expenses corresponding to the construction of these roads, expenses which it is impossible to estimate exactly but which are not less than half the maintenance costs at least, and which are above all capable of a great increase if, owing to the development of motor traffic, it becomes necessary, in the interests of safety, to improve existing roads (removal of dangerous points, installation of signal systems) or even to devote entirely to such traffic certain roads already in existence or that would have to be made.

In such a case the motor services would only pay at the most 1 600 millions towards expenses of the order of 2 700 millions. Over and above the subsidies they enjoy they are exempt from those taxes which, as we have seen, fall heavily on rail transport, and, better still, they only pay 60 % of the construction and upkeep expenses of the roads used by them, while the railway has to meet the whole of such expenses, the sum total of which is about 1/3 of its total receipts.

In the French Colonies the situation is in general much the same.

In Tunis, for example, the motor services do not have to contribute to the upkeep and construction expenses of the roads and their receipts are not taxed, while the State deducts 25 % of the railway receipts in taxes and it has to support all the upkeep expenses of the permanent way.

In Algeria, on the other hand, the regulations are a little less systematically unfavorable to the railways, for the motor services pay a tax of 10 % on their receipts and the Prefect fixes in the case of each enterprise a contribution for the use of the road, a charge that is however inferior to the actual expenses.

A curious but very convincing proof of the facilities afforded to road competition by its freedom from taxation and the arrangement of an artificial gradation of the rates can be given by the following facts : motor competition which in England has been in full force for many years has only developed in France and Belgium in an alarming fashion since 1926, i. e. since rail transport was heavily taxed in France, and both in France and Belgium had to submit to such rates as

---

(1) According to the statistics supplied by the Ministry of Finance, the returns of the different taxes in 1927 were as follows:

| | |
|---|---|
| Taxes collected to the profit of the State . . . . . . | 619 millions |
| Taxes collected to the profit of the Departments. . . . | 69 » |
| Taxes on petrol: 866 millions, 9/10th of which were paid by motors . . . . . . . | 779 » |
| Taxes for local services rendered . . . . . . . . | 60 » |
| Local taxes (Law of 9 August 1926); no general statistics of its results are kept but the sum total does not exceed . . . . . . . . . | 80 » |
| Total . . | 1 607 millions |

would cover all its expenses, while a large part of those of the motor services are borne by the whole country.

* * *

§ 12. — *Have you undertaken to work regular motor services as an additional enterprise of your railway? How has this enterprise been organised and what have been the results ?*

*Please state :* a) *what sort of motor services form this enterprise, especially if they are services between places joined by the railway or services whose only connection with the railway is that they act as feeders; and* b) *what is the length, the passenger and goods traffic, and the economic results to your railway of working such services?*

In the face of the advantages bestowed by the public authorities on motor services the railways have often found that the only possible way to maintain the struggle against competition was to profit by the same advantages themselves. They therefore considered the creation of motor services which would certainly compete against them but the profits of which would be assured to them.

In Belgium such motor services were directly formed by the railway itself. The National Light Railway Company which as we have said is able to obtain directly the concession of motor services, asked for and obtained the concession of some 50 such services; however not more than half of these seem assured of the possibility of carrying on.

In Spain, such services are not directly worked by the railways but by private individuals with whom an agreement has been made as regards correspondence and return services.

In France the large Railway Companies, on the initiative of the Ministry of Public Works, each formed an affiliated company which with the cooperation of the minor railways of the regions served by their lines, was intended to assure on behalf of the railway the necessary motor services or, in rare cases, to fight the competing services which were detrimental to the railway, or, in the majority of cases, to provide wherever it was needed in the interests of passengers a service which would act as a connection and feeder to the railway and serve under the most favorable conditions such localities as were not situated on the railway.

These companies were formed too recently to enable the replies given to furnish us with any precise information about their results.

However since receiving the replies made to our questionnaire we have received more detailed information which forms the subject of Appendix VI.

It would seem that the end in view has been attained . Certainly these companies do not seem likely to show brilliant results from the financial point of view. To enable a motor service for passenger traffic (which seems to be their principal province) to succeed it must in effect, it would seem, either assure the town services of a thickly populated centre, which is not the role of the Companies Affiliated to the Railways or run a service in direct competition with the railway, between places where there is much traffic. The Railway Companies except when a competitive service has already been installed between points where through lack of agreement there is no suitable service assured, generally prefer to modify their train services as much as possible to recapture the traffic they are losing.

In certain particular cases however the existence of such competition shows that no matter what efforts are made, the railway in such cases is not the most advantageous method of transport. The only solution in such cases is to suppress completely the railway service. The French Railway Companies have successfully done this in several places. The Nord Light Railway Company has done the same thing and substituted a bus service in place of a daily train between Boulogne and Bonningues.

In every way the affiliated company within its sphere of action will set the standard and assure the regulation of fares, besides giving an example of order, regularity and security which will enable serious and legitimate undertakings to exist and render service without being in fear of other undertakings of inferior quality; the public will certainly benefit thereby.

⁂

§ 13. — *Have you organised on your railway a mixed service of direct railway transport and regular motor services, and what are the principles upon which such an enterprise is organised?*

*Please state the agreements made with the concession-holders of regular motor services which enable the direct transport of goods to be carried out and the direct journeys of passengers with or without a choice of route by rail or road.*

a) *Passengers.* — Such organisations exist at the present in general in a fragmentary fashion only. However certain arrangements have been made for combined tickets available both on the railway and on the road section, and sometimes available either by one or the other; but this latter case is rare; it is nearly always a question of values. Certain special cases of interest may be mentioned.

The French State Railways, for example, which serve seaside places at some distance from their main lines usually issue at their large stations direct tickets valid for all the journey, the end part of which is by bus. The railways of Algeria and Tunis, the Portuguese Railway Companies, and the Railways of Indo-China and Yunnan have quoted parallel cases. Here it is a question of bus journeys which are really an extension of the railway or which join up railways between which there is no communication.

As an example of a feeder service the Nord Railway Company cites the services it assures on race days at Chantilly under the following conditions : it established a very fast and complete train service between Chantilly and the Nord Station; however the competitive motor services for the same price, usually that of a second class ticket, picked up passengers all over Paris. The Nord Railway Company therefore made an agreement with the « Société des Transports en Commun de la Région parisienne » to form in Paris a bus service which would pick up passengers and take them to the Nord Station for their journey to Chantilly for the same price as the ordinary ticket. On their return the same buses will assure their distribution over Paris. This organisation has been very succesful. The decline in the number of passengers has been stopped and an increase seems to have started.

As far as the tourist services organised in France, for example, by many of the Railway Companies, are concerned, it is nearly always possible for travellers to combine rail and road travel by means of a ticket bought beforehand for the whole journey.

b) *Goods.* — For goods on the other hand the direct road and rail services have already been developed rather more, but under a special form, that of porterage and cartage undertakings both for collecting and delivering goods; these services are greatly developed. According to circumstances they are carried out either by horse vehicles or by motors, and provide a service which from the technical point of view is on the whole very satisfactory.

However, these services have not limited motor competition for two reasons : in general they only serve a rather small area round the stations, and their rates are high.

In effect, if such enterprises carefully arrange the goods for transport by the railway each consignment keeps its individual character on the railway and the reduction in price corresponding to transport in large quantities does not apply to them. On the other hand the collecting organisation for grouping consignments together which we have spoken of before allows of such advantages and this explains its success.

However, the railways are thinking of going still further and allowing a larger number of consignors and consignees to profit by the motor services by suppressing the handling necessary on loading into the trucks and on unloading by the use of containers. As this seems to be an important question we will consider it in paragraph 14.

* * *

§ 14. — *What other means have you made use of to avoid or to diminish on the one hand the effects of road competition on the traffic of your railway, and on the other to contribute to the development of motor services as feeders?*

To make the report clear we have usually grouped together in the answers to the preceding paragraphs the remarks which were made on the point raised by these questions.

However as far as the transport of goods was concerned we have kept till this present part of the report particulars of a special organisation which the French Railway Companies are making trial of, and which in many cases enables railway transport to benefit by many of the advantages offered by the motor.

What in effect are the chief of these advantages? Door to door transport, suppression of complicated packing, easy identification of goods, simplicity of the formalities of consigning, suppression of long and costly handling operations.

All these advantages would fall to the lot of the railway if instead of sending goods piece by piece they were collected on consignment in a container which could be carried by road as far as the station, loaded onto a truck, off loaded on arrival onto a lorry and taken to its destination by road.

Very conclusive trials have already been made; the results also have the advantage of being of use not only in the struggle against road competition but also in facilitating the transhipment of goods into boats and between railways of different gauge; and we think that a general use of such methods would be the source of a closer collaboration between the two kinds of transport, the road services assuring the short distance and pick up services, and the railway, thanks to its great technical capacity, assuring the long distance transport between the collecting and distributing points.

Appendix VII gives certain supplementary information about the results already obtained.

* * *

## CONCLUSIONS.

From our report it is evident that motor competition is a normal problem. It forms a new method of transport which attracts those who are economically interested in making use of it.

For this reason such competition has deprived the railway of much of its traffic in the following cases :

— Private transport of passengers in their own motors;

— Public transport in areas which are not or only poorly served by the railway;

— Transport of goods between private individuals at good profit;

— Public transport of goods in certain cases where it has been possible to combine rapidity of transport with low rates thanks to the importance of the traffic;

— Tourist undertakings.

This competition is however more or less limited; in particular, except in rare cases, it has not had much effect on long distance passenger traffic; it has not effected and could not, so it would seem, effect weighty goods nor the long distance transport of goods. The railway could guard against cases where competition seems likely to develop by profiting by its technical possibilities of speed and safety, and by modifying its rates, thanks to the adjustment of the fixed prices, as much as is necessary.

Despite the difficulties presented by such a modification, and difficulties due to administrative traditions which have outlived their usefulness, the railway could in this way fight road competition upon an equal footing in an efficacious way, especially if for passenger traffic it makes use of affiliated companies which would maintain for it the profits which it has the right to count upon and develop its traffic by establishing supplementary communications by safe, comfortable, and regular motor services, and also if it makes general the use of containers of such dimensions as would best suit each sort of traffic thus assuring to the railway the advantages which the motor possesses from this point of view.

Unfortunately the public authorities have considered it their duty to take measures against the railway which though more or less justified in so far as they broke up what was in fact a sort of monopoly, today in many countries constitute an illegitimate handicap against the railway in favour of the road. This could be prevented by observing the following rules in the future :

*a)* Subsidies, which are perfectly justified when it is a question of enabling useful enterprises to be started or to carry on, should only be granted to services which are not in direct competition with the railway which is first interested in favouring feeder services and aiding the general development of the region served by it, and should therefore be able to intervene more directly in the choice of services to be subsidised.

*b*) The taxes which fall on the different kinds of transport should be made equal, preferably by lowering those which the railway has to pay, while both road and rail should be obliged to collaborate in the maintenance of the public resources but in the same proportion, which could easily be estimated by the value of the services they render, namely by the amount of money they collect from the public.

*c)* The expenses of each kind of transport as regards the construction and upkeep expenses of the track or roads used by them should be equalised so that each would always have to include in the fares charged the necessary amount sufficient to cover the interest on the capital laid out on the construction and upkeep of the aforementioned track or roads.

*d)* The railway should be authorised to put into immediate force, after due publicity, such rates, guaranteed times, or transport regulations between specified stations or on specified lines, as would enable it to keep any traffic it seems likely to lose through road competition.

If these measures of simple equality and of general interest were undertaken, rail and road could collaborate without any difficulty to the greater benefit of their patrons. To consider the problem merely from the point of view of competition is to limit it unduly. Such a point of view is doubtless the most easily seen and naturally comes first to mind because the favorable regulations by which the motor services benefit facilitate such competition and because it is easier for a new comer to take a part of his forerunners' traffic than to create new. But it is just such a creation of new traffic that should be the end and the fruit of collaboration, and it is under the aspect of this collaboration that the problem should be considered in order to realise the best technical and economical arrangement to the greatest advantage of the whole country.

QUESTION 1.

## Importance

| *Country or region included within the limits of a Railway Company.* | Number of motor vehic | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | of passengers. | | | | | | | |
| | 1920. | 1921. | 1922. | 1923. | 1924. | 1925. | 1926. | 1927 |
| Belgium | ... | 14 999 | 21 839 | 28 366 | 44 361 | 55 604 | 59 108 | 62 6 |
| France | 156 872 | 194 452 | 240 143 | 290 928 | 371 348 | 473 551 | 541 438 | 642 7 |
| Algeria | 9 051 | 10 501 | 12 717 | 14 682 | 23 356 | 28 683 | 34 663 | ... |
| Tunis | 2 046 | 2 427 | 2 847 | 3 498 | 4 582 | 5 752 | 7 120 | 7 1 |
| Damas-Hamah and Extensions | ... | ... | ... | ... | ... | ... | 3 542 | ... |
| Smyrna-Cassaba and Extension | ... | ... | ... | .. | ... | ... | ... | 5 |
| Reunion | .. | ... | ... | ... | | ... | ... | ... |
| Tonkin | ... | ... | ... | .. | 1 616 | 2 144 | 2 644 | 3 1 |
| Portuguese Railways | ... | ... | ... | ... | ... | ... | ... | ... |
| Portuguese Beira Alta Railway | ... | ... | ... | ... | ... | .. | ... | 1 6 |
| Spain | ... | ... | ... | ... | ... | .. | ... | ... |

---

(1) For the region included within the limits

(2) These figures include the total number

## tor traffic.

Appendix I.

| se for the transport | | | | | | | |
|---|---|---|---|---|---|---|---|
| of goods. | | | | | | | |
| 920. | 1921. | 1922. | 1923. | 1924. | 1925. | 1926. | 1927. |
| ... | 5 657 | 9 868 | 18 911 | 23 452 | 31 141 | 33 084 | 34 174 |
| 79 076 | 92 730 | 120 794 | 154 434 | 200 895 | 244 875 | 267 470 | 305 587 |
| 1 282 | 1 755 | 2 055 | 2 362 | 3 215 | 3 719 | 4 338 | ... |
| 149 | 220 | 245 | 289 | 330 | 372 | 406 | 437 |
| .. | ... | ... | ... | ... | ... | 246 | (1) |
| ... | ... | ... | ... | ... | ... | ... | 260 (1) |
| 108 | 145 | 190 | 266 | 394 | 680 | 791 | 947 (2) |
| ... | ... | ... | ... | 64 | 123 | 172 | 181 |
| 7 332 | 7 873 | 8 282 | 9 301 | 10 410 | 13 825 | 18 178 | 21 516 (1) (2) |
| ... | ... | ... | ... | ... | ... | ... | 110 (1) (2) |
| ... | ... | 50 949 | ... | 89 910 | .. | 138 241 | (2) |

Railway Company given in the first column.
cles used for passenger and goods transport.

QUESTION 1 (*continued*).

## Consumpti

| *Country or region included within the limits of a Railway Company.* | Fuel used by motor vehi | | | | |
|---|---|---|---|---|---|
| | 1920. | 1921. | 1922. | 1923. | 1924. |
| Belgium | ... | ... | ... | ... | 134 83 |
| | ... | ... | .. | ... | ... |
| France | 467 030 | 413 760 | 556 770 | 731 970 | 861 670 |
| | ... | ... | ... | ... | ... |
| Algeria | ... | .. | ... | ... | ... |
| Tunis | 3 282 | 3 569 | 3 912 | 5 309 | 6 467 |
| Damas-Hamah and Extensions | ... | ... | ... | .. | ... |
| Smyrna-Cassaba and Extension | ... | ... | ... | ... | ... |
| Reunion | ... | ... | ... | ... | ... |
| Tonkin | ... | ... | ... | ... | ... |
| Portuguese Railways | ... | ... | ... | ... | ... |
| Portuguese Beira Alta Railway | ... | ... | ... | ... | ... |
| Spain | ... | ... | ... | ... | ... |

fuel

Appendix I (*continued*).

| metric tonnes). | | | *Kind of fuel used.* |
|---|---|---|---|
| 1925. | 1926. | 1927. | |
| 156 877 | 107 894 | 138 636 | Petrol. |
| ... | ... | 11 388 | Alcohol for the fabrication of the national fuel. |
| 1 041 560 | 1 069 350 | 1 196 395 | Petrol. |
| 37 139 | 29 875 | 30 830 | Benzol. |
| ... | 21 613<br>(6 first months) | 50 206 | Petrol (provinces of Oran and Alger only). |
| 9 141 | 10 685 | 13 174 | Petrol (quantities imported). |
| ... | ... | ... | ... |
| .. | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

## Number and extent in kilometres of the regular motor services.

| *Name of the Railway Companies and extent of their railway lines.* | 1927 | | *Remarks.*<br>*Information concerning the development of the lines before 1927.* |
|---|---|---|---|
| | Number. | Extent. | |
| **Belgium.** | | | |
| Belgian National Railway Company, 4 728 km. | 216 | 3 255 | (Passengers only.) |
| National Light Railway Company, 4 490 km. | 59 | 865 | .. |
| **Spain.** | | | |
| Central Argon Railway, 302 km. . . | 10 | ... | ... |
| Madrid to Saragossa & Alicante Railway, 3 670 km. | ... | 9 981 | Passenger services granted an exclusive conce sion. |
| **France & Colonies or Protectorates.** | | | |
| State Railways, 9 064 km. . . . . . . | .. | 15 000 | ... |
| Alsace & Lorraine Railways, 2 021 km. | 139 | 3 420 | Number and extent from 1920 to 1926 :<br>Number: 12 26 38 58 69 91 12<br>Km.: 152 267 603 1 234 1 286 1 809 2 6 |
| Est Railway, 5 027 km. . . . . . . . | ... | 10 000 | Extent in 1923 : 5 000 km. |
| Midi Railway, 4 210 km. . . . . . . | ... | 20 409 | Extent in 1925 : 10 714 km. |
| Nord Railway, 3 830 km. . . . . . . | 246 | 8 096 | ... |
| Paris-Orleans Railway, 7 812 km. . . | 509 | 15 767 | Number and extent from 1920 to 1926 :<br>Number: 57 184 244 293 365 401 44<br>Km.: 4 134 6 011 8 096 9 712 11 506 12 672 13 6 |
| Paris, Lyons & Mediterranean Railways, 9 821 km. | 1 511 | 40 411 | ... |
| Tarn Departmental Railways, 150 km. | 37 | 1 128 | ... |
| Landes Railway Company, 363 km. . . | 5 | 236 | 1 line, 42 km. in 1922.<br>2 lines, 94 km. in 1924.<br>4 lines, 207 km. in 1926. |

## Number and extent in kilometres of the regular motor services

| *Name of the Railway Companies and extent of their railway lines.* | 1927 | | *Remarks.*<br>*Information concerning the development of the lines before 1927.* |
|---|---|---|---|
| | Number. | Extent. | |
| General Light Railway Company, 669 km. | 5 | 125 | Extent in 1920 : 20 km.<br>Extent in 1922 : 74 km. |
| Ain Tramway Administration, 436 km. | 9 | 418 | ... |
| Deux-Sèvres Departmental Tramways, 198 km. | ... | 330 | ... |
| Algerian lines of the Paris, Lyons and Mediterranean Railway, 1 186 km. . | ... | 6 314 | ... |
| Gafsa Phosphate & Railway Company, 441 km. | 5 | 517 | ... |
| Tunisian Railway Company, 1 580 km. | ... | 2 569 | Extent from 1920 to 1926 :<br>Km. : 216, 724, 1 092, 1 393, 1 622, 2 052, 2 569, (these figures do not include the conceded lines of the Tunisian Motor Company). |
| French Indo-China and Yunnan Railway Company, 860 km. | 2 | 163 | ... |
| Reunion Railway, 127 km. . . . . . . | 11 | 366 | Number of lines : 1920/21 1922 à 1924<br>6 7 |
| **rtugal.** | | | |
| Portuguese Beira Alta Railway Company, 253 km. | ... | 655 | ... |
| Portuguese Railway Company, 1 073 km. | 268 | 10 026 | Number and extent from 1920 to 1926 :<br>1920/21<br>Number : 23 75 81 89 100 226<br>Km. : 737 2 957 3 268 3 528 3 724 6 326 |

*Note.* — The Railway Companies who are not mentioned in this table either could not or did not reply.

## Extent of the regular motor services which could compete with the railways.

| RAILWAY COMPANIES. | Passengers. | Goods. | — |
|---|---|---|---|
| | Extent of the lines in 1927. | Extent of the lines in 1927. | |
| **Belgium & Colonies.** | | | |
| Belgian National Railway Company.<br>National Light Railway Company<br>Nord-Belge | ... | ... | Extent of the passenger lines from 1923 to 1926 :<br>Km. : 288. 1 069. 1 694. 2 216. |
| **France, Algeria, Tunis, Colonies & Protectorates.** | | | |
| Alsace-Lorraine | 1 354 | 1 257 | Extent of the lines since 1920:<br>*Passengers :*<br>40, 212, 329, 513, 625, 773, 921.<br>*Goods :*<br>41, 74, 74, 258, 356, 596, 1 061. |
| Est | 1 700 | 3 00 | |
| Midi | 2 725 | | |
| Nord. | 1 260 | 5 560 | Extent of the passenger lines in 1926: 495 km. |
| Paris-Orleans | 4 507 | | Extent of the lines from 1920 to 1926:<br>775, 1 054, 1 441, 2 211, 2 701, 3 278, 3 879. |
| Paris, Lyons & Mediterranean | 12 770 | ... | |
| Landes Railway Company | 62 | 8 184 | |
| Light Railways | 51 | ... | |
| Deux-Sèvres Departmental Tramway Company. | 136 | .. | |
| Algerian lines of the Paris, Lyons & Mediterranean. | 1 000 | ... | |
| Tunisian Railway Company | 445 | | The greater number for passenger services (of which 250 km. are weekly services).<br>Extent of the lines in 1921: 240 km. 1923: 323 km.; 1925-26 : 445 km. |
| Smyrna-Cassaba. | 600 | ... | |
| Indo-China & Yunnan Railways | 138 | ... | |
| Reunion. | 160 | ... | |
| **Portugal & Colonies.** | | | |
| Portuguese Beira-Alta Railway Company. | 413 | | |
| Portuguese Railways | 3 052 | | Extent of the passenger and goods lines from 1920 to 1926:<br>52,52, 140, 140, 316, 2 179. |

The other Railway Companies consulted did not reply or were not able to estimate such competition, although sure of its existence.

# APPENDICES IV, V, VI and VII.

QUESTION 4.

## Traffic of the motor services in competition

| RAILWAY COMPANIES. | Traffic of the motor services in competition with the railways. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Passengers. | | | *Remarks.* | Goods. | | |
| | 1927. | | | | 1927. | | |
| | Vehicles. | Passengers. | Passenger-kilometres. | | Vehicles. | Tonnage. | Ton kilom |
| | | (in thousands) | (in thousands) | | | (in thousands) | (in th and |
| **Belgium and colonies.** | | | | | | | |
| Belgian National Railway Company. | ... | ... | ... | ... | ... | ... | ... |
| **Spain** (1). | ... | ... | ... | ... | ... | ... | ... |
| **France, Algeria, Tunis, colonies and Protectorates.** | | | | | | | |
| Est | ... | ... | 7 500 | ... | ... | ... | 5 0 |
| Alsace-Lorraine | 85 | 450 | 9 200 | Vehicles in service from 1920 to 1926 : 4, 16, 26, 34, 44, 51, 60. | .. | 75 | 2 5 |
| Midi | ... | ... | ... | ... | ... | ... | ... |
| Nord | 202 | 1 981 | ... | ... | 230 | 202 | 6 7 |
| Paris-Orleans | ... | ... | 17 000 | ... | ... | ... | 7 |
| Paris, Lyons and Mediterranean | 612 | ... | ... | Passengers 352 lines in all in 1927.<br>Traffic for 185 lines, 1 911 000 passengers.<br>Receipts for 231 lines, 14 000 000 fr. | 243 | 92 | in 192<br>133 lin<br>the 15<br>the rai |
| State | . | 182 | ... | ... | ... | ... | ... |
| Algerian lines of the P. L. M. | ... | ... | ... | ... | ... | ... | ... |
| Indo-China & Yunnan Railways. | 49 | 17 | ... | ... | ... | ... | ... |
| Damas-Hamah Railway | ... | ... | ... | Reduction of 16 % in passenger traffic and 25 % in goods traffic. | ... | .. | ... |
| **Portugal.** | | | | | | | |
| Beira Alta Railways | ... | ... | ... | ... | ... | ... | |
| Portuguese Railways | ... | 547 | ... | Number of passengers carried from 1920 to 1926 :<br>1920 33 000<br>1923 40 200<br>1922 43 600<br>1924 318 900 | ... | ... | ... |

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(1) As far as the Railways of Andalusia, Central Aragon, Madrid to Caceres and Portugal and the West of S
The other Railway Companies consulted did not reply or

## Railways as compared with that of the Railways.

APPENDIX IV.

| Traffic of the railways in 1927. | | | | Comparison as a percentage of the motor to the railway traffic. | | | |
|---|---|---|---|---|---|---|---|
| Passengers. | | Slow goods. | | Passengers. | | Goods. | |
| Number of assengers. | Number of passenger-kilometres. | Number of tonnes. | Number of tonne-kilometres. | Number of passengers. | Number of passsenger-kilometres. | Real tonnage. | Number of tonne-kilometres |
| n thousands) | (in thousands) | (in thousands) | (in thousands) | | | | |
| 219 129 | 5 780 487 | 86 903 | 8 923 429 | ... | ... | ... | ... |
| 57 949 | 3 269 907 | 29 199 | 4 393 441 | ... | ... | ... | ... |
| 112 777 | 3 390 645 | 58 973 | 7 353 005 | ... | 0.22 | ... | 0.07 |
| 71 620 | 1 589 736 | 49 604 | 3 963 554 | 0.62 | 0.57 | 0.15 | 0 06 |
| 28 946 | 1 627 756 | 15 131 | 1 982 550 | ... | ... | ... | ... |
| 145 499 | 4 025 355 | 57 980 | 7 643 432 | 1.36 | ... | 0.34 | 0.08 |
| 79 342 | 3 831 423 | 21 106 | 3 571 267 | ... | 0.41 | ... | 0.02 |
| 10 976 | 6 508 718 | 41 072 | 2 051 008 | ... | .. | ... | ... |
| 181 678 | 5 002 742 | 28 712 | 3 341 476 | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | .. | ... |
| ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... |
| 795 | 30 013 | 225 | 13 913 | ... | ... | ... | 0.4 |
| 14 335 | 589 822 | 2 766 | 380 622 | 3.8 | ... | ... | ... |

rid to Saragossa and Alicante, North of Spain, and Salamanca to the Portuguese frontier, are concerned.
able to estimate such competition although sure of its existence.

QUESTION 6.

Rates of the reg

| Railway Companies. | Passengers. | | |
|---|---|---|---|
| | Motor kilometric rates. | Railway kilometric rates. Comparison as a percentage with that of the motor service. | Motor tonne-kilom rate. |
| **Belgium & Colonies.** | Values converted into gold-centimes. | | Values conve |
| Belgian National Railway Company. | 3.5 to 7. | 5.1 in the 2nd. class, *i. e.* 146 to 66%. | Irregular. |
| National Light Railway Company. | 3.5 to 7.7. | ... | ... |
| **Spain.** | | | |
| Madrid to Saragossa & Alicante Railways. | 9 to 16 in the 1st class,<br>8 to 13 in the 2nd class,<br>10 in the 3rd class,<br>according to the weight of the vehicles. | 1st 2nd 3rd class<br>8 6 4<br>i. e. for the 2nd class, 75 to 46 %. | Very variabl |
| North of Spain Railway . . | 6 to 16. | 5 to 6.5 i. e. 83 to 37 %. | Irregular. |
| Aragon Central Railway . . | ... | ... | ... |
| **France, Algeria, Tunis, Colonies & Protectorates** | | | |
| State . . . . . . . . . . . | 4 to 6.<br>8 to 12 for seaside resorts. | 1st 2nd 3rd class.<br>9 6 4<br>*i. e.* 300 to 50 % for the 2nd class. | ... |
| Est. . . . . . . . . . . . | 4 to 7. | ... | ... |
| Alsace-Lorraine . . . . . . | 5. | ... | ... |
| Midi . . . . . . . . . . . | 5 to 6. | ... | 32. |
| Nord . . . . . . . . . . | 5 to 10.<br>6 for subsidised services. | On the Nord in a general way the lowest fares on the motor services correspond to 2nd class rates. | ... |

APPENDIX V.

**r services.**

| *ds.* | | | |
|---|---|---|---|
| *way tonne-kilometric te. Comparison as a rcentage with that of motor service.* | *Rules concerning the fixing of the rates.* | *Evolution of the rates during the last few years.* | |
| *gold-centimes.* | | | |
| than the 1st class rates ow 150 km. | For authorised services are fixed by Public Authority. | Cannot be calculated. | ... |
| ... | 7 maximum per passenger-km. for conceded lines. | ... | ... |
| ... | Official rates of conceded lines fixed by the Central Junta. | ... | Very variable. |
| 7.2 to 32.3. | The rates are suggested to the Companies who are free to refuse them. | Passengers : 3.3 to 4 gold-centimes before 1919 *i. e.* 55 % of the present rates. | ... |
| ... | ... | ... | Very variable. |
| 100 km. :<br>per tonne-km. for ex- ess goods service.<br>per tonne-km. for ordi- ry goods service, 1st se- es. | No rule. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| the Nord, in general, e motor rates at 100 km. mall packages except- l) are the same as for dinary slow goods 1st ies rates and for collect- g and cartage combined. | ... | Nord Railway : *as far as passenger rates* are concerned the bus services have tried to keep their fares equal to 2nd class railway fares.<br>*As far as goods* are concerned, before 1925 the motor rates were comparatively higher than the railway rates. | ... |

QUESTION 6 (*continued.*)

| *Railway Companies.* | *Passengers.* | | |
|---|---|---|---|
| | *Motor kilometric rates.* | *Railway kilometric rates. Comparison as a percentage with that of the motor service.* | *Motor tonne - k tric rate.* |
| | *Values converted into gold-centimes.* | | *Values converted* |
| Paris-Orleans | 6 to 10. | ... | 20 to 60. |
| Paris, Lyons & Mediterranean | 2 to 12. | ... | 15 to 88. |
| Landes Railway | 5. | 3.2, 2nd class *i. e.* 64 %. | ... |
| Light Railway Company | ... | ... | ... |
| Departmental Railways | 6 to 10. | ... | ... |
| Indre Tramways | 6. | ... | ... |
| Algerian State Railways | ... | ... | .. |
| Algerian lines of the P. L. M. | 3.5 to 5. | ... | ... |
| Gafsa Railway | 3 to 5. | 10-7.2 & 5.2 according to class; *i. e.* 240 to 140 % for the 2nd class. | ... |
| Tunisian Railway Company | 5. | Equal. | Irregular. |
| Indo-China & Yunnan Railways. | 2.5. | Equal to the fares of the 4th class. | ... |
| Damas-Hamah Railway | 4. | ... | 16. |
| Smyrna-Cassaba Railway | ... | ... | .. |
| Reunion Railway | 4 to 10. | 6 and 4 for 1st and 2nd classes, *i. e.* equal to 140 % for the 2nd class. | 42 to 66. |
| Ain Tramway Administration | 8 to 10. | 4 *i. e.* 50 %. | ... |
| **Portugal.** | | | |
| Portuguese Railways | 2.5 to 28.5. | For a journey of 10 km. the minimum railway fare (special rate 2nd class) is 40 % greater than the minimum motor fare. | 1 to 3.5. |

| *ds.* | | | |
|---|---|---|---|
| *lway tonne-kilometric te. Comparison as a rcentage with that of e motor service.* | *Rules concerning the fixing of the rates.* | *Evolution of the rates during the last few years.* | |
| *-centimes.* | | | |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | .. | ... | ... |
| ... | ... | .. | Very variable. |
| ... | .. | ... | ... |
| ... | .. | ... | ... |
| ... | .. | ... | Very variable. |
| way fares lower than ad fares. | ... | ... | ... |
| ... | ... | ... | ... |
| els rates sligthly higher road than by rail. | The rates of the Tunisian Motor Company and those of the Tunisian Transport Society must be approved by the Tunisian Administration. | | ... |
| .. | ... | ... | ... |
| ... | ... | .. | ... |
| ... | ... | ... | Very variable. |
| 100 km. ·47.5 tonne-km. r express goods; 10 to for slow goods; *i. e.* %. | ... | ... | ... |
| According to class. | ... | ... | ... |
| ... | ... | ... | ... |

APPENDIX VI.

# Subsidiary Transport Companies of the large French Railways.

The large French Railways have considered the formation of Subsidiary Transport Companies, the aim of which would be to create, in complete collaboration with the railway in the district in which they function, transport services acting as feeders to the lines in regions where the geographical situation of the lines does not allow of rapid communications and where the importance of the exchange traffic does not justify the building of new lines.

These companies should also make it possible to coordinate the efforts of the different undertakings so as to avoid the danger of their operating separately and coming into competition with the railway lines.

The formation of these Companies was encouraged formally by the public authorities early in 1928.

During 1928, Subsidiary Transport Companies were formed by the State, the Est, the Nord and the Alsace-Lorraine Railways.

As each of the large Railway Companies wished to count the money it subscribed as capital expenditure, they had to obtain the authorisation of the Ministry of Public Works and submit the by laws of the companies to its approval.

The Ministry has also reserved to itself certain rights in overseeing, through the medium of the large railways, the functioning of the services of these auxiliary companies, in particular as regards the programme of the routes to be opened and the conditions under which these will be worked. It has also enjoined that the railway companies must always retain ownership of two thirds of the shares so that the policy of the subsidiary company will always be controlled by the Railway Company.

These subsidiary companies are still only in formation on the Paris-Orleans, Midi, and Paris, Lyons & Mediterranean Railways; it should be noted that these railways which serve regions where there is important tourist traffic, have already for several years followed the policy of forming agreements with certain motor undertakings by which they are enabled to extend their services by tourist excursions.

The constitution of the subsidiary companies has, under the form of a Limited Liability Company grouped under the ægis of the large Railway Company, the Administations of the minor railways situated within its region and for whom the organisation of motor services was an even greater necessity than for the large Companies, and of some of the more important motor enterprises which brought to the Company the cooperation of their experience in road transport. The members of the Company engage themselves to exploit their services in the spirit of the widest collaboration possible by avoiding all competition between themselves and offering to the company the execution of those public transports required of them. .

The systems of running motor services which were put into force during 1928 can be ranged in three categories :

1. Direct operating such as has been practised on the State, the Est, and the Nord Railways;

2. Exploitation leased to a third party with or without supplying rolling stock after payment of an agreed upon price per vehicle-kilometre and ultimately a premium on the receipts. This system is the one more or less generally in use in the subsidiary companies of the Est and Nord Railways;

3. The concession to a third party of the title of concession-holder or correspondent of the Company and the advantages attached thereto for a small rent paid to this latter. This system has been made use of by the subsidiary company of the State Railways.

During the trial period a subsidy, which may go as far as completely guaranteeing any operating deficiency, is allotted to the subsidiary company by those who apply for the service, which divide up the expenses between them in proportion to their interest in the service.

The subsidiary companies have also reserved the right of appealing for subsidies to the communes, departments and the State in those cases where the service required by a region does not seem of such interest to the company that it should assume all the risks.

The first services inaugurated by the different Railway Companies were intended to realise various objects of which the principal are as follows:

a) *To replace the deficient train services by buses.*

The State Railways, for example, have organised services of this kind on the Falaise to Coulliboeuf lines where a poorly frequented train service could be economically replaced by a motor bus.

Between Neuilly and Isigny the State Railways have also completely suppressed the train service and replaced it by motor buses.

The suppression of trains causes many difficulties both on the part of the interested population and the State control.

In effect, especially when this suppression bears on the minimum of three stipulated trains, the bus must fulfill all the obligations of the trains it replaces, and even then it is usually only authorised by the controlling authorities in so far as the inauguration of such a bus service gives rise to a manifest improvement in the service.

A more acceptable solution is to put the stipulated trains nearer together in the timetable and cover the very late and very early services by bus, and also those services that are very little used.

b) *To create cross communications between places situated fanwise on the railway between which communication is only possible by long and complicated journeys.*

It was with this object in view that the Subsidiary Company of the Nord Railway, for example, created the services between Saint-Quentin and Arras, Bruay and Lille, and Compiègne to Senlis and Dammartin, the Subsidiary Company of the Est Railway the services between Rheims and Troyes, Meaux and Sens, Rheims and Hirson, the Subsidiary Company of the State Railways services between Caen and Rennes, between Evreux and Rouen, and the Paris-Orleans Railways, a service between Poitiers and Limoges.

c) *To prevent or to combat competition against the railway by a feeder service of the Company which, while answering to traffic requirements already in existence, will create new streams of traffic.*

The subsidiary company can in such a way be led to incorporate in its working any private services already in existence.

As examples of this kind of exploitation the Lille-Lens route and the services of the Béthune region organised by the Subsidiary Company of the Nord Railway may be cited.

d) *To give the public in advance those facilities which projected lines will procure them later on.*

Trials have been made also with combined railway and bus tickets as well as with tickets available for either bus or railway services serving the same areas.

The rates applied on the bus services have varied according to kind and have had, in particular, to take into consideration the necessities of local competition when granting reduced rates. The fares have varied from 0.25 to 0.40 per passenger-km. It has been possible to grant reduced rates of 0.25 and 0.30 on those routes for which communal or departmental subsidies have been obtained.

The situation of the services worked varies from day to day. Each large Railway Company possesses at the present (January 1929) from 5 to 10 regular routes of a useful character of perhaps 150 to 600 km. per day (93 to 373 miles). But these figures will greatly increase during the coming months. The tourist lines must be considered apart; on certain railways like the Paris, Lyons & Mediterranean these have actually reached a length of 11 000 km. (6 835 milles) and are in general worked by agreement with a private contractor.

The undertakings in progress at the present only concern passenger and mail transport, as the transport of ordinary goods by road has not yet entered upon the period of realisation on most of the subsidiary companies. It raises moreover more delicate problems than does the transport of passengers and mails. The Paris-Orleans however is considering the possibilities of door to door transport.

The Railway Companies have recognised the necessity of making common use of the results of their experiments so that profit may be made of the experiences of each company and a uniform line of conduct adopted for those problems that arise under identical conditions in each of the auxiliary companies.

The Ministry of Public Works has moreover ever since the formation of the subsidiary companies required such collaboration and its practical interpretation by common services with the neighbouring subsidiary companies, by recommending the organisation of a periodic conference between the different Railway Companies.

A conference of the heads of the different Railway Companies has thus been organised and has already been able to draw up a programme.

The problems which have been decided to be worth of common study deal with the rates, and technical and administrative questions.

*As far as the rates are concerned* mention must be made of the conditions under wich passengers with ordinary or special tickets are admitted to the bus services formed to replace the train services. As far as tickets are concerned, it can be agreed that when the bus services are intended to be a supplement to the trains required by law it is best to apply simply bus rates.

When, on the other hand, the bus replaces one such train without any improvement as far as the whole service is concerned, the conditions under which passengers are admitted to such buses will be exactly the same as for the trains.

But when in consequence of the reduction in the number of trains the service is notably improved, a small supplement will be charged for the use of the bus in addition to the ordinary fare.

*From the technical point of view* without entering in detail into the orders for stock for which each company has varying facilities in its relations with the makers, it appears worth while to form an agreement with motor makers to obtain certain uniform conditions especially as regards payment, fines for delay in delivery, inspection at the factories, inspection conditions, technical stipulations, as regards construction and equipment, etc.

*From the administrative point of view* the exemptions from the luxury tax enjoyed by vehicles used for public transport has been claimed and obtained by most of the subsidiary companies. But in this matter it has also seemed necessary to obtain an official order making this measure general for all the orders given by the subsidiary companies of the Railways.

The question of parking places in the station yards reserved for so-called « correspondence » vehicles is variously interpreted by the different departments. The conference of the Subsidiary Companies judged it opportune to ask the Management Committee of the large Railway Companies to petition the Minister of Public Works to grant a modification of the prefectural decrees which will make it possible, in order to assure proper order in parking, to give a priority of position in favour of the correspondence services organised by agreement with the large Railway Companies.

APPENDIX VII.

# Transport by containers.

### *General idea.*

The Railway Companies who tried to find a way of remedying the inconveniences caused in the case of fragile goods or those needing expensive packing by the amount of handling needed in loading and unloading when it was a question of consignors or consignees who were not directly on the railway, or when it was a question of exchanging goods with a different method of transport or with a different gauge railway, thought that it might be a solution of the problem to use containers which would form part of the body of the trucks and provide a unit readily handled.

It seemed to them that such containers would also be effective in many cases against motor competition by realising the chief of those advantages which have made possible the success of certain transports by motor lorries.

The container can in effect be placed at the disposal of the consignor, who himself loads the goods; the container is then collected at his door by a motor lorry and taken to the station where, by the cranes it will be loaded on, and then secured to the flat trucks. At the other end of the journey it will be delivered to the consignee in the same fashion.

Customers find in this method the advantages of economy in packing, in delivery and collection at the door, in the reduction to a minimum of handling operations at the stations, and in the rapid release of rolling stock which thus secures them from any unpleasant surprises about demurrage charges for delay in the unloading of a truck.

### *Practical application.*

The traffic in small packages constitutes a test field for transport by containers in which there is much active motor competition.

The factors: rapidity of transport, economy of packing, diminution of the risks of damage and loss, are essential in this kind of transport which feeds the fast goods traffic.

The customers who make use of fast goods services are accustomed to make use of the services of collecting agencies who will collect and deliver at their door and free them from the necessity of consigning or collecting their goods at the station.

But this intermediate agent is often expensive and cases have been known where the collecting companies which were obliged to equip themselves with motors to carry out their services, not finding in the rates of the railways sufficient reductions to leave them satisfactory profits, find it more advantageous to carry out the so-called express transport entirely by road.

The container is a retort to such diversion of traffic, whether it be used by the customer himself if its capacity is suitable or whether it be placed at the disposal of the collector who will load it at his depot in one or more lots.

Transport by containers economises for the railway the handling of separate packages which falls to its charge, and also assure it a gain on the circulation of its stock which in consequence justifies a rating concession intended to encourage the use of such containers.

The Nord and the Est Railways, for

example, have made a special rate for the transport of goods in containers which form a section of the body of a truck of a model approved by the railway.

The principle is the assessment of the goods only in the case of transport of a full load and the application of a very reduced rate, calculated according to capacity, on the return of the empty container.

The basis of this rating system is as follows (tax and increases not included):

| — | | Containers whose capacity does not exceed 7 m³ (247 cubic feet). | Containers whose capacity is more than 7 m³ (247 cubic feet) but less than 10 m³ (353 cubic feet). |
|---|---|---|---|
| | *Slow goods.* | Francs. | Francs. |
| | up to 50 km. (31 miles) . . . | 1.50 | 2.00 |
| for each km. (0.621 mile) | 50 to 200 km. (31 to 124 miles. | 0.03 | 0.04 |
| | 200 to 300 km. (124 to 186 miles). | 0.02 | 0.03 |
| over and above | 300 km. | 0.015 | 0.025 |
| | *Fast goods.* | | |
| | up to 50 km. (31 miles) . . . | 2.50 | 3.25 |
| for each km. (0.621 mile) | 50 to 200 km. (31 to 124 miles). | 0.05 | 0.065 |
| | 200 to 300 km. (124 to 186 miles). | 0.03 | 0.04 |
| over and above | 300 km. | 0.025 | 0.035 |
| | | per unit ; station charges and loading and unloading costs included. | |

*Technical realisation.*

In order to make known to the public the advantage of this method of transport the Nord Railway Company built several containers of models especially intended for transport by motor lorry, the chief characteristics of which (taken from the diagrams and photographs of figures 1 to 8) are as follows:

| | | Metres. (Feet and inches). | |
|---|---|---|---|
| Containers ; Nord Railway type, small model. | Exterior length | 2.360 (7 ft. 9 in.) | Interior : volume 7.500 m³. (265 cubic feet). |
| | — width | 1.970 (6 ft. 5 1/2 in.) | Tare : 1 000 kg. (2 200 lb.). |
| | — height | 2.160 (7 ft. 1 in.) | Useful load : 3 tons. |
| Containers, large model . . . . . . . | Exterior length | 2.960 (9 ft. 8 1/2 in.) | Volume : 10 m³. (353 cubic feet). |
| | — width | 2.050 (6 ft. 8 3/4 in.) | Tare : 1 200 kgr. (2 645 lb.). |
| | — height | 2.160 (7 ft. 1 in.) | Useful load : 3 tons. |

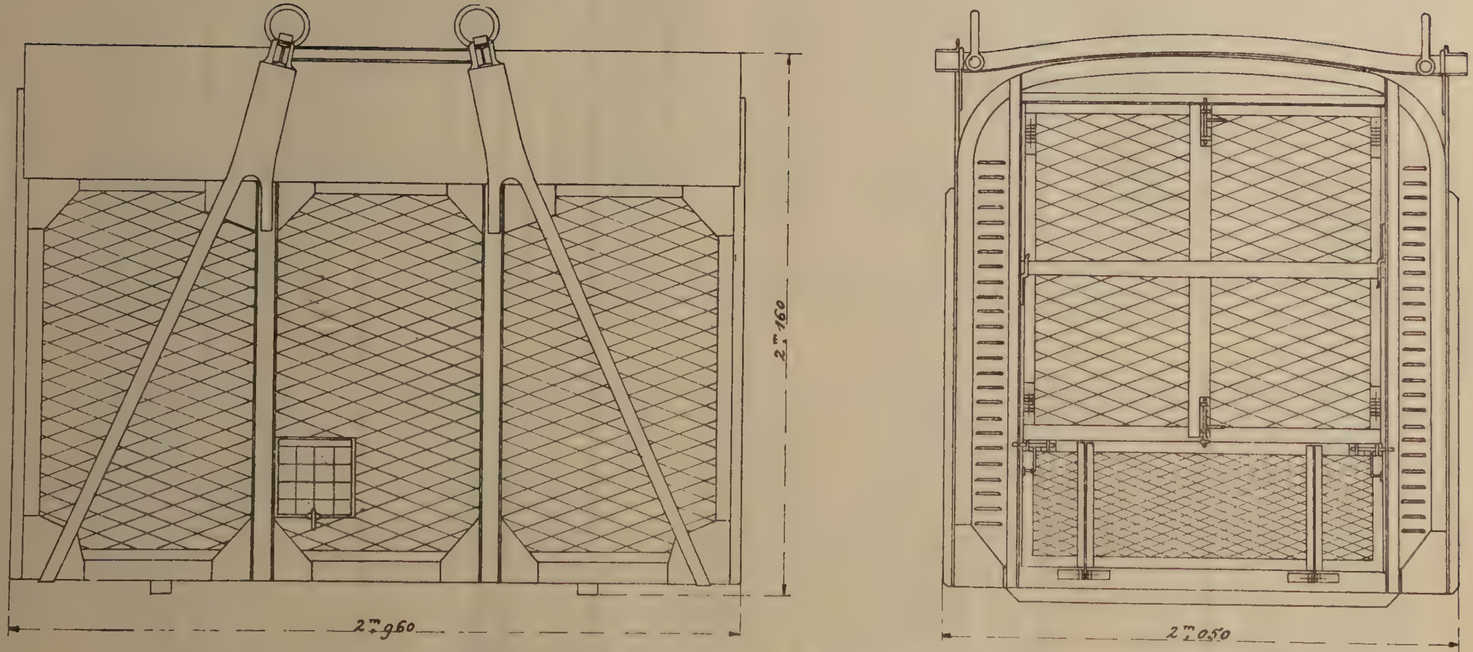

Fig. 1. — Nord Railway type of container (large model).

Tare : 1 200 kgr. (2 645 lb.) — Volume : 10m³ (353 cubic feet).
Useful load : 3 tons.

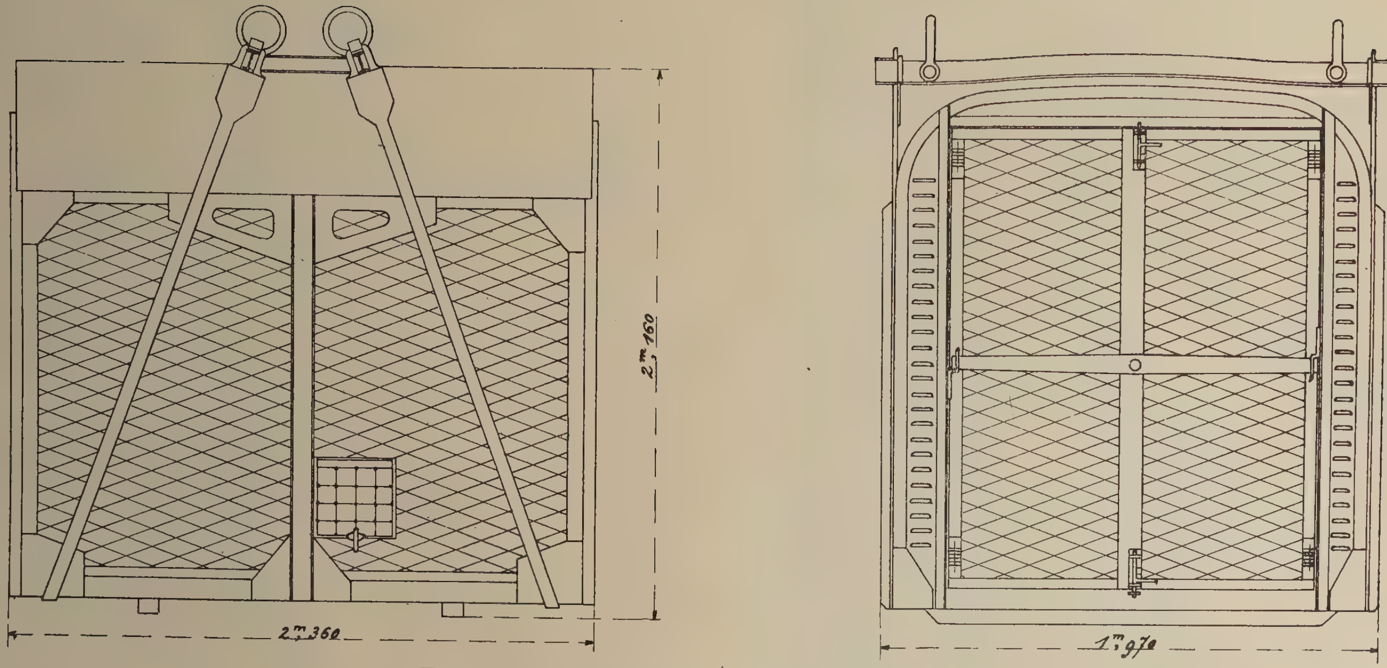

Fig. 2. — Nord Railway type of container (small model).

Tare : 1 000 kgr. (2 200 lb). — Volume : 7 500 m³ (265 cubic feet).
Useful load : 3 tons.

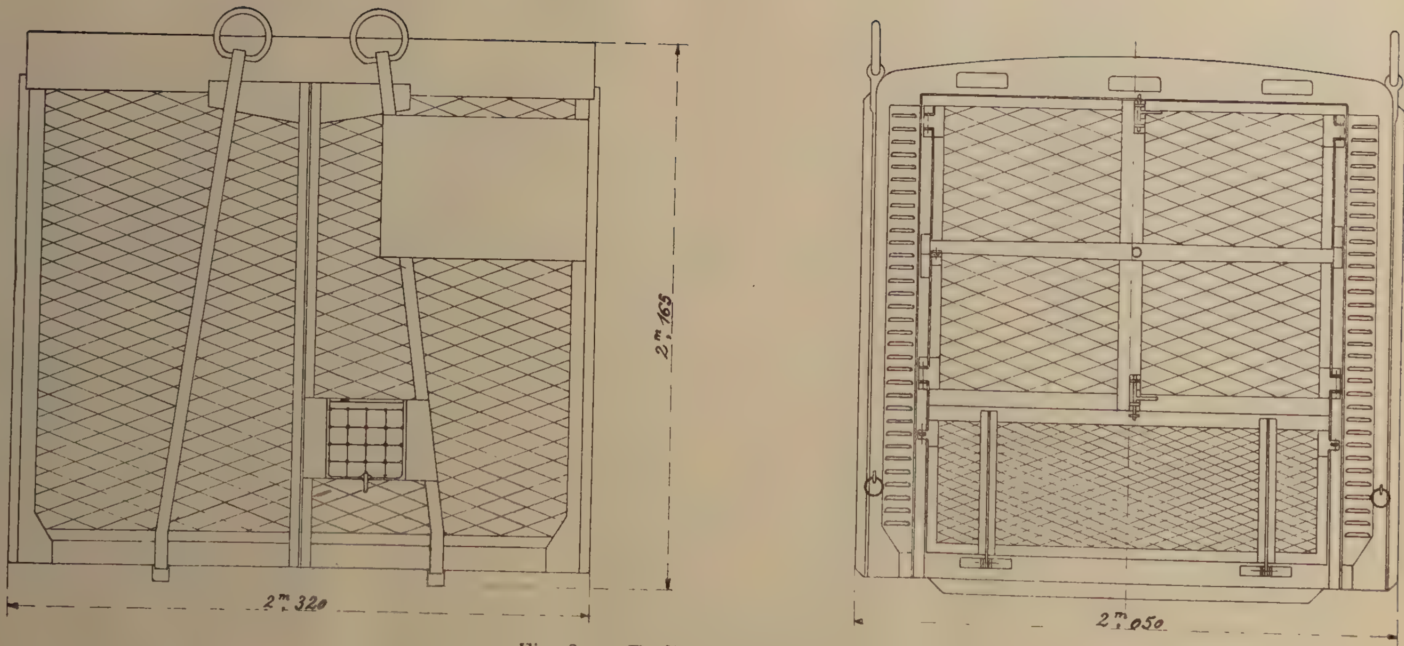

Fig. 3. — English type of container.

Tare : 700 **kgr.** (1543 lb.). — Volume : 8 500 $m^3$ (300 cubic feet).
Useful load : 3 tons.

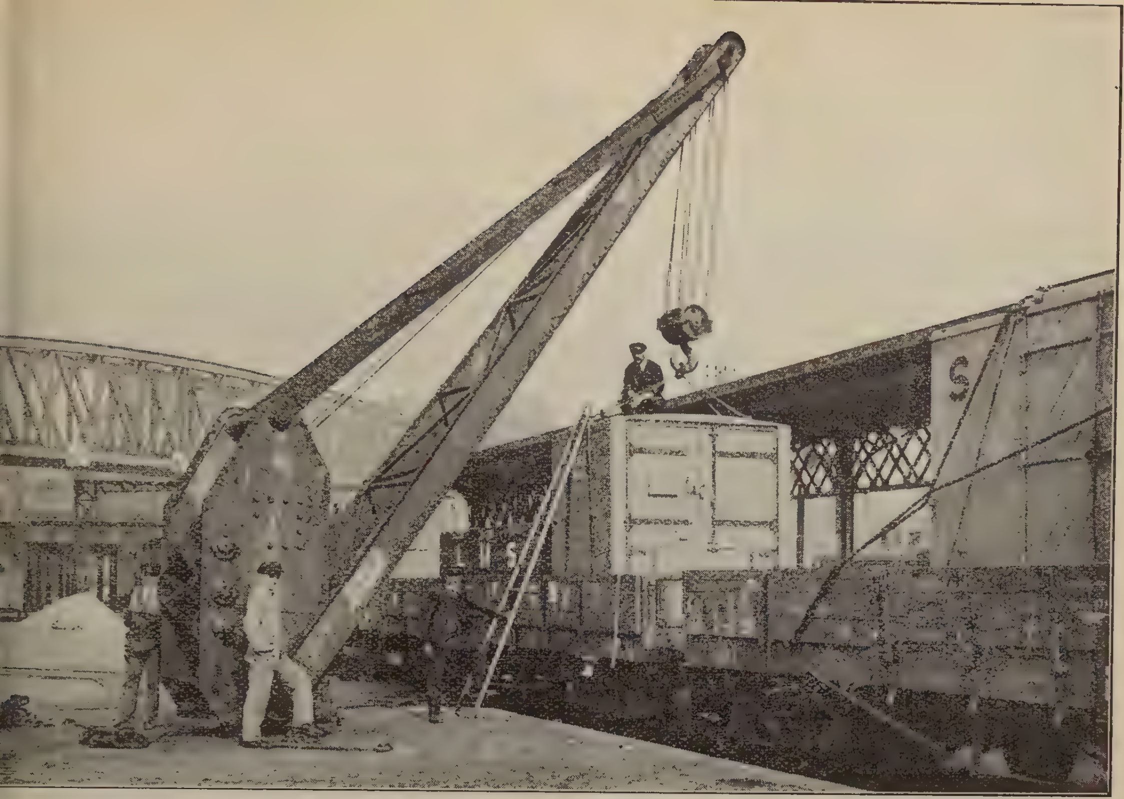

Fig. 4. — English container being loaded onto a truck (London, Midland & Scottish Railway).

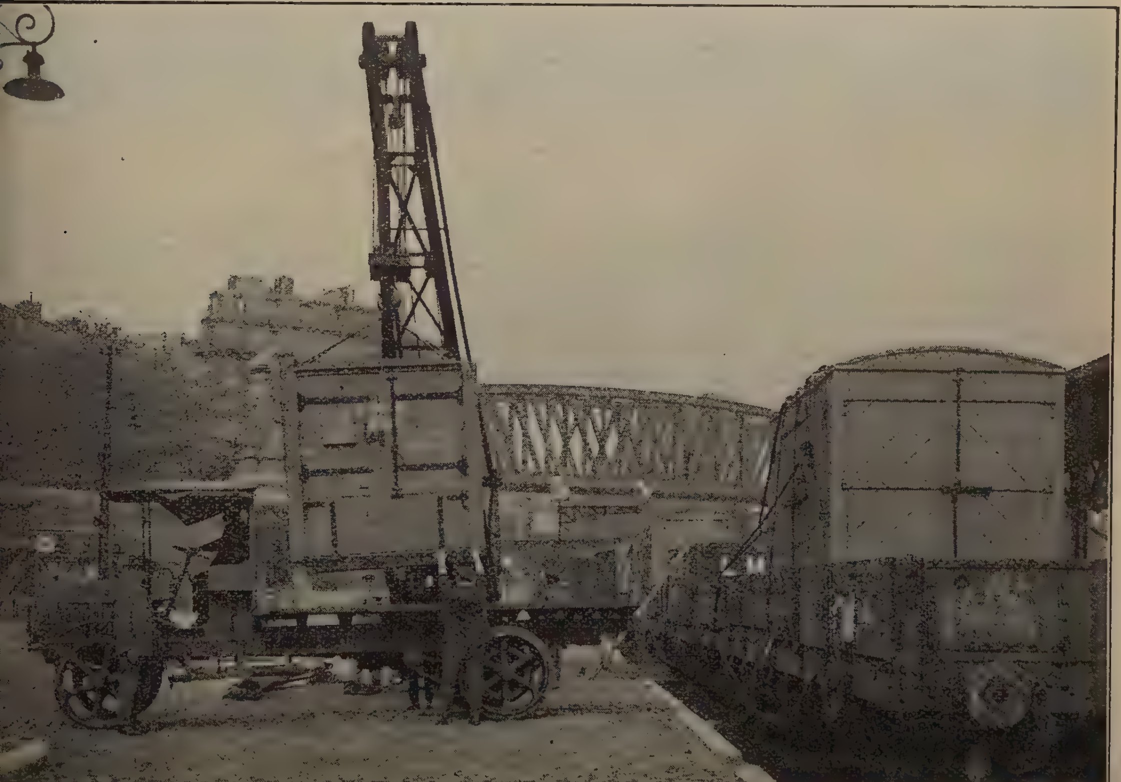

Fig. 5. — English container being loaded onto a lorry (London, Midland & Scottish Railway).

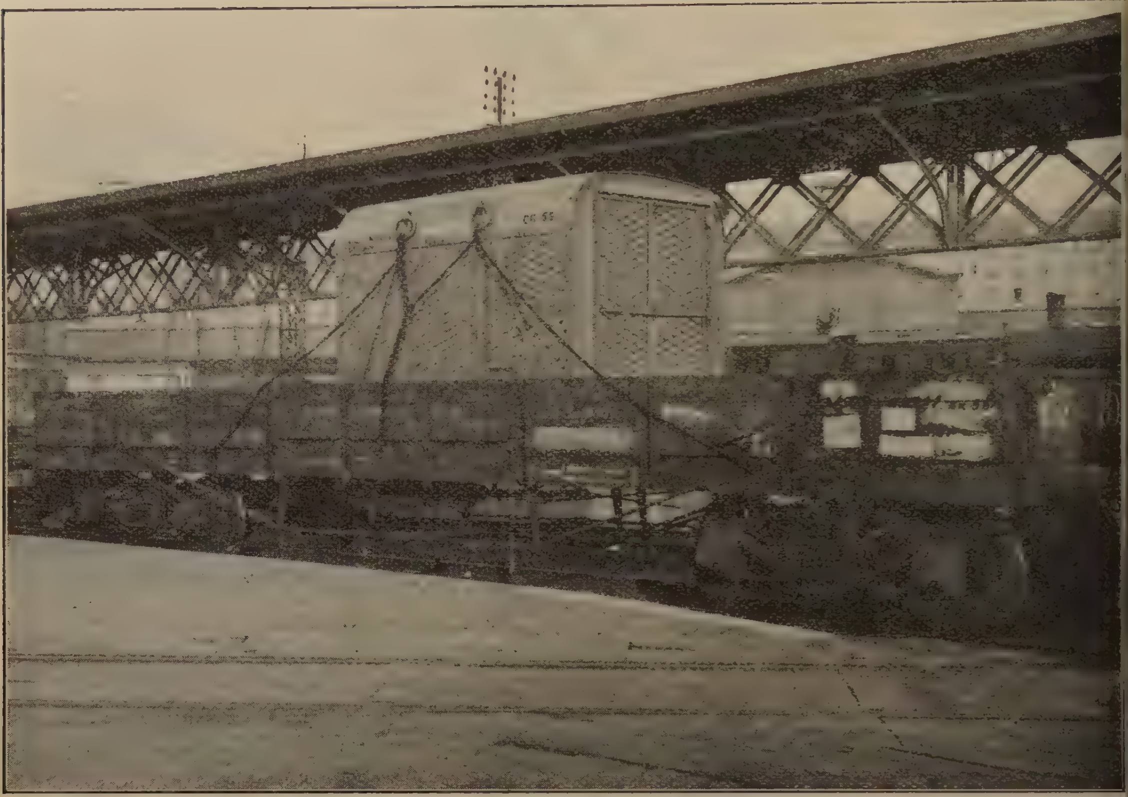

Fig. 6. — Nord Railway type of container, large model, loaded and stowed on a truck.

As this Railway, during the trials made by it, knew of the results already obtained in England, it also built containers of a type similar to those used in that country, with the following characteristics:

| | | |
|---|---|---|
| Exterior length | 2.320 m. (7 ft. 7 3/8 in.). | Volume : 8.5m³ (300 cubic feet). |
| — width | 2.050 m. (6 ft. 8 3/4 in.). | Tare : 700 kgr. (1 543 lb.). |
| — height | 2.163 m. (7 ft. 1 1/8 in.). | Useful load : 3 tons. |

About 300 kgr. should be added to the tare for the padding and inside fitting necessary for certain loads such as velvet. Dimensions and weight have been studied so as to enable these containers to be easily loaded by the cranes available at the stations and so that they can be easily stowed onto motor lorries of the usual type.

The opening at the back facilitates the loading and unloading, and makes it possible to carry out, for example, the collection or distribution of small packages at several depots in the town, all

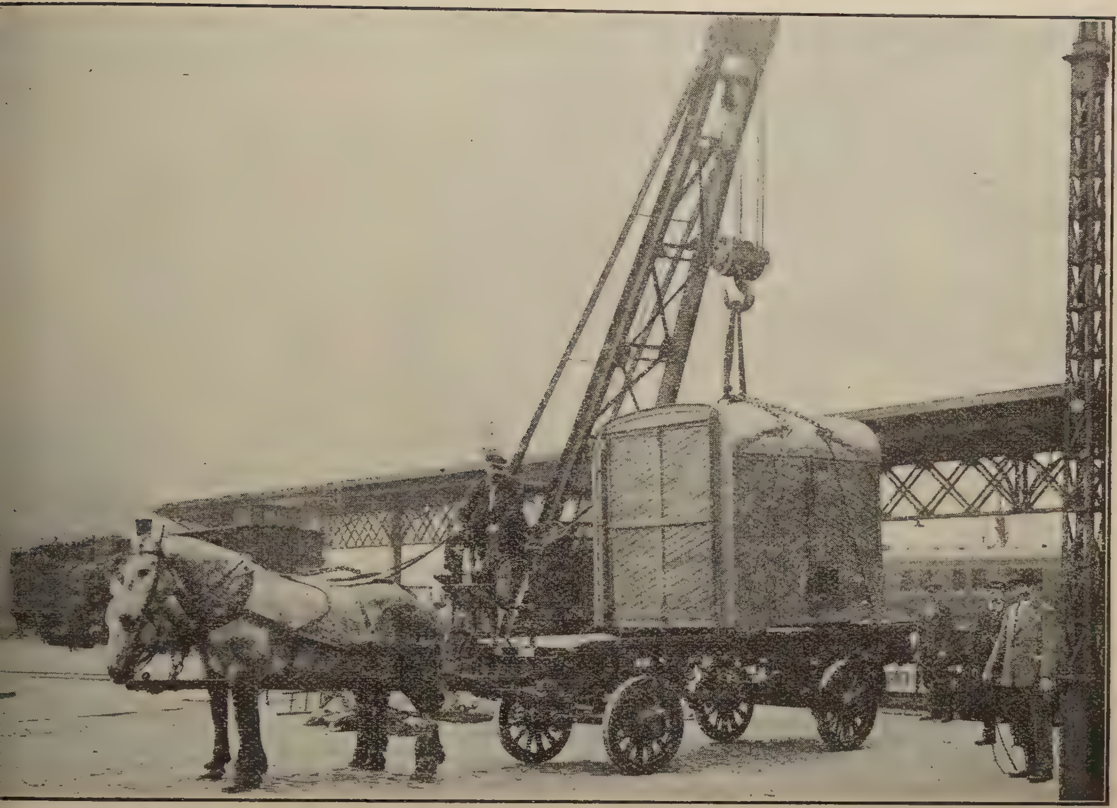

Fig. 7. — Nord Railway type of container, small model, stowed on a lorry and ready for delivery to the address of the consignee.

goods being handled from the back of the lorry. The container thus works in the same way as an ordinary delivery lorry and completely realises the desired objective, i. e. it acts as a vehicle collecting or delivering from door to door as if each customer had his private siding.

The experiments made were especially conclusive in the case of the regular transport to Paris of textile fabrics from Roubaix and velvet from Amiens; these materials were placed in lined out containers provided with separate partitions so that there was practically no need for any other packing in the case of these fragile goods.

An interesting adaptation of these containers is in effect heir employment for regular transports in which case a specialisation of their dimensions and arrangement assures the most favourable conditions for the rapid and economic transport of those goods which suffer from much handling.

But the Railway Companies are also trying to make an agreement with the cartage agents for the formation of pick

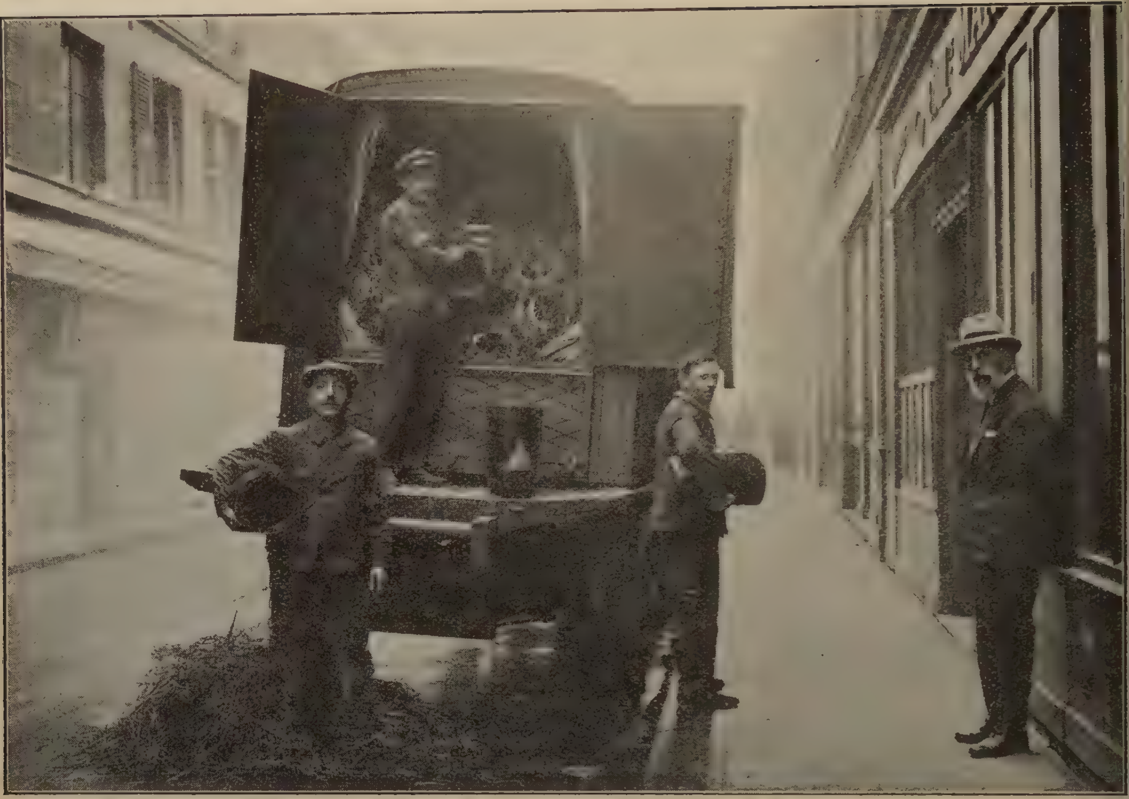

Fig. 8. — Delivering a load of plumbago crucibles.

up services round important railway centres using containers distributed by motors to several loading points.

Motor lorries will collect these containers in the evening and bring them to the station where they will be loaded on to the flat trucks, specially arranged and set aside for such transports, standing on the crane line.

These collections can be made as late as the train service allows. Transported by the night train the trucks loaded with the containers will arrive at the Paris stations early in the morning and the consignees can take immediate delivery and arrange distribution to the different addresses by lorries which on their return journey will bring bach the empty or reloaded containers to the station.

In this way transport by containers, which is moreover encouraged by the rating system and benefits by the fixed rates established for competitive services, may become a fruitful method of collaboration between the railway and the road.

# SUPPLEMENT

When drawing up our report on Question XIII for the Railway Congress, we were not able to deal with the replies given by the Italian Companies.

We therefore proposed to make a supplementary report of this information which we only received after the report had been drawn up.

We will therefore give below a summary of the replies in the order of the questionnaire :

§ 1. — The number of vehicles in use in Italy on the first of January 1928 was estimated as follows :

| | |
|---|---|
| Motors belonging to private individuals . . . . . . . . | 113 800 |
| Lorries . . . . . . . . . . | 34 100 |
| Motor cycles . . . . . . . . | 79 700 |

The number of vehicles used for public transport services was estimated as:

| | |
|---|---|
| 1921. . . . . . . . . . | 1 315 |
| 1922. . . . . . . . . . | 1 907 |
| 1923. . . . . . . . . . | 2 397 |
| 1924. . . . . . . . . . | 3 001 |
| 1925. . . . . . . . . . | 3 581 |
| 1926. . . . . . . . . . | 4 331 |
| 1927. . . . . . . . . . | 4 931 |

i. e. an increase of 375 % in 1927 as compared with 1921.

The greater number of such vehicles are used to transport passengers and their luggage.

§ 2. — The regular services are rapidly developing. About one third of their total extent lies near the railway to which they bring the traffic of the regions served by them.

The development of the regular concession-holding lines is figured as follows :

| | | |
|---|---|---|
| 1921 . . . | 28 566 km. | (17 750 miles) |
| 1922 . . . | 34 356 — | (21 348 — ) |
| 1923 . . . | 38 796 — | (24 107 — ) |
| 1924 . . . | 45 482 — | (28 075 — ) |
| 1925 . . . | 50 182 — | (31 182 — ) |
| 1926 . . . | 55 682 — | (34 600 — ) |
| 1927 . . . | 63 882 — | (39 695 — ) |

§ 3. — Part of the motor services are in competition with the railway. The State Railways are not able to fix the extent of such services; but as far as Emilia is concerned their length is estimated at more than 610 km. (379 miles), i. e. more than five times the length of the railway.

§ 4. — The importance of the competition could not be estimated. The Emilian Railway Company states that it is serious and growing every day.

The Central Canavese Railway on the contrary does not suffer from competitive passenger transport services because the government concession gives it the monopoly of such transport.

§ 5. — The regular motor services are governed by the Royal Decrees of 9 May 1912 and 2 December 1928.

Such services are divided into two catogories :

Definitely established services (for a period of 9 years) :

Provisional services, the duration of which may be renewed every 5 months. The former may be subsidised; the latter never are.

The services do not share in the construction and upkeep expenses of the roads; they only pay for the stamps on the passenger tickets, the taxes for the supervision exercised by State organisations and the taxes which fall on all commercial enterprises.

The working of such services is the object of a concession granted by the Ministry of Transport. The concessions of subsidised services have the character of monopolies. In other cases there is the possibility of competition but the Administration is free to prevent this.

The concession-holders of regular motor services enjoy the preference in obtaining the concession of adjacent lines; the same privelege is given to the exploiters of provisional lines who wish to turn these into definite concessions.

The rates are approved by the Ministry of Transport.

§ 6. — The passenger rates vary according to the economical and geographical conditions of the regions served. They can be estimated on the average, in gold centimes, as 9.5 per passenger km. (15.3 per mile), the extreme values being 4.9 and 19 gold centimes per km. (7.9 and 30.6 per mile).

In Emilia the passenger rates in force on the motor services are 35 % higher than on the railway.

§ 7. — The regular passenger services, especially those which join important places by a shorter route than the railway, are in competition with the latter. However the State Railways are not in a position to say how much they lose thereby. The Emilian Railway states that the number of passenger-km. which in 1926 was 16 776 000 (10 260 000 English ton-miles), had fallen in 1927 to 15 166 000 (9 275 000 English ton-miles), and in 1928 to 14 295 000 (8 742 400 English ton-miles), i. e. a diminution of 14 % in 1928 in comparison with 1926, on account of the increase in motor traffic.

There is also a very serious competition in the case of goods traffic; within a radius of 300 km. (186.4 miles) such services are assured of an important tonnage, but it is impossible to estimate the loss due to this in the falling off of railway traffic.

§ 8. — The passenger traffic lost to the railway on account of private cars and by intermittent services is considerable.

All the same the Italian State Railways estimate that the most important competition in the case of goods is due to vehicles utilised by private individuals on their own behalf or belonging to contractors who ply intermittent services.

It has not been possible to calculate the loss.

§ 9. — *Passengers*. The deserting of the railway for the motor is due especially, according to the Emilian Railway, to the too low commercial speed of the trains. In regions where the competition is particularly strong this railway Company has made supplementary trains with a tram like service, i. e. stops according to the wish of the passengers. It is also contemplating making its lines of standard gauge and electrifying them in order to combat competition.

As far as the tourist region services are concerned the public again are in favour of the motor, but the Railway Companies do not attach much importance to this as these services are only intermittent and only function during a small part of the year, and also they cause a special passenger traffic which is partly beneficial to the railway.

*Goods*. — The motor is preferred because of the facilities it offers for door to door transport collection and delivery, and because it does away with part of the handling.

To remedy this state of affairs the State Railways grant reductions in rates to important enterprises who take charge of a door to door transport lorry service; measures of this kind are in force on the Biella-Turin-Milan triangle and will be extended to other regions.

§ 10. — The Italian State Railways have not considered a general reduction of their rates because of the effect that such a measure would have on those kinds of traffic where there is no competition, but they have undertaken particular arrangements to make the competition motor services side with them, or to fight against them.

The Emilian Railway has reduced its rates by 50 % on the lines where there is the most competition.

§ 12. — The Italian Railway Companies up to the present have not organised or confided to other enterprises the working of regular motor services.

§ 13. — The State and Emilian Railways have made arrangements with certain motor services for the issue of tickets valid for the through motor and railway journey.

The fares are generally those in force on each of these Companies.

§ 14. — To limit the effects of competition the Emilian Railway has sanctioned special arrangements which give consignors who guarantee a fixed annual tonnage of goods a notable reduction in rates.

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The replies furnished by the Italian Railway Companies to the question on the effects of road competition confirms the conclusions of our general report on the subject.

In Italy, as in other countries with which we have been concerned, the motor services deprive the railway of traffic, often to an important extent, because of their priveleged situation by which they profit from the point of view of the construction and upkeep expenses of the roads they use. The Railways have been obliged, in order to retain their traffic, to lower their rates, to grant special concessions to motor services working in collaboration with them, to modify their by-laws, to create trains with tram like services, etc...

As far as passenger traffic is concerned, however, the Italian Railways are better protected than for example the French, from the fact that the plan of the lines is fixed by the Ministry of Transport, as well as the fares, and because this organisation can also prevent unfair competition.

[ 385. (01 ]

# REPORT No. 1

**(all countries except America, the British Empire, China, Japan, Belgium, France, Holland, Portugal, Spain and their Colonies)**

## ON THE QUESTION OF PENETRATION RAILWAYS (SUBJECT XVII FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1) (2),

By Enrico MELLINI,

ENGINEER, CHIEF INSPECTOR AT THE INSPECTION OF RAILWAYS, TRAMWAYS, AND MOTOR CARS HEADQUARTERS OFFICE, ROME.

Figs. 1 to 4, pp. 2669 and 2670.

### I. — General remarks.

If the importance and the actuality of the problem with which we are dealing were to be judged from the replies received to the questionnaire drawn up in agreement with our colleagues and addressed (for the countries assigned to us) to about 70 Railway Administrations belonging to the International Association, we should be led to conclude that it was a question of secondary importance. Actually, 18 Railways alone have replied; 5 replies were entirely negative, and 1 gave information of little value; the 12 others supplied greater data, information and comment having some value, which as a whole only concerned the feeder railways in the different countries.

It would be interesting to know for what reason so many great Companies did not desire to collaborate directly in the investigation of a question which is undoubtedly of the greatest and most immediate importance for the Railway world and in particular for Railways conceeded to private companies. It is possible that it may be found in the fact that we are dealing with a problem of quite unusual magnitude and complexity.

When the numerical statistics relating to the various Railway Companies are not accompanied by comments explaining the local operating conditions, competition, topographical figuration of the country, the need of the latter, and the various methods of transport the use of which can be considered, they do not always result in much clearness through their too great simplicity. It would be better in this case, to deal with considerations, variations and appreciations of a general character, frequently exceeding the limit of the field, vast though it be, of the railways, to attain a general view both wider and clearer of the means of communication in general, such as modern technical knowledge offers for the various traffics. Two great organisations then stand out and dominate all the others : the Railways and the Motor vehicle.

The question of road transport, the

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(1) This question runs as follows: « Penetration railways. — Construction: a) Penetration railways in new countries; b) Feeder railways in all countries. »

(2) Translated from the French.

great importance of which must be recognised, both for the vitality and the development of the Railways as for the well being of the Nations, will be examined during the Madrid session by the fourth section (question XIII); but obviously, it will undoubtedly arise in connection with many other subjects of discussion, and especially in connection with that with which we are dealing, because the construction of penetration railways in new countries, and of feeder railways in all countries ought also to be considered, and in a special manner, with regard to its relation with the technical and commercial advantages which the organisation of public road services by motor omnibuses or lorries may show.

Before starting the detailed examination of the two parts of question XVII, we will therefore consider briefly from the point of view that affects us directly, whether it is desirable to build penetration or feeder railways in view of the competition of automobile services on the roads. We have no intention of trespassing on the territory of question XIII, as we simply desire to point out the principles and ideas upon which this competition is based, and which modern technical knowledge has recently brought to light, and furthermore would make an interesting and valuable subject for discussion in this section.

Modern technical experts, when considering this question, base their investigations upon certain considerations and observations, that we will use as our starting point when enquiring into this important problem; we will reproduce them below in a concise form.

1. Operating costs of the motor omnibus per kilometre, can be taken as being about one fifth of those of an ordinary railway train. On the other hand, the relative transportation capacities are more favourable towards the railway; for the same train and the motor omnibus, it is as 10 to 1. The characteristic feature of automobile transportation is therefore, before all, its limited quantity, whereas, on the other hand, the essential condition regulating railway transportation, is the great volume even at the cost of economy.

2. The economical and useful radius for automobile services varies round about 100 km. (62 miles); this forms the normal limit of their most effective competition with the railway.

3. A motor omnibus service requires a much lower capital expenditure and lower operating costs than a railway; it is therefore most economical where the traffic is small and where its growth will not exceed certain known limits. On the other hand, a railway line is more costly as the country through which it runs is more hilly. It is rather in moutainous country, that the motor omnibus finds its best field of service.

4. The financial results given by motor transportation diminishes when the vehicle has to pass the night away, or when a return load can not be guaranteed.

If these remarks prove to us that for railways in general, and for light railways in particular, the transportation monopoly only partly exists, and that it has quite disappeared in some places, we must not conclude however, that they have come to the end of their usefulness, and of their development.

There are certain commodities, and requirements, which the railway alone can satisfy; there are certain situations which have to be considered from a quite special point of view, and for which the establishment of railways, whether light or others, and of limited capacity may represent not only a necessity, but even a duty. Furthermore, the transportation of goods over long distances whether inside the boundaries of the country or from one country to another, is developping quickly on a considerable scale, and those regions in which the commercial and agricultural activity has up to the present met local requirements, are at the present time altering their methods so as to increase their output by producing fruit and other agricultural products in general which are despatched to other consuming centres at great distances either at home or abroad.

Today, it is necessary that light railways when out of date should be modernised, their alteration meeting the various needs of modern life, the improvement of their methods of operation increasing the speed of the trains, reducing to the minimum the transhipment of many classes of goods, the reduction of the cost in general and, as a result, the cost of transport. All these steps are reflected by a greater development in the economical life of each country and by the general growth of the traffic.

One of the methods available by which the railways may renew the lack of capacity of their fixed plants, and regain the traffic lost, is electrification. In Italy, a certain number of light railways and tramways have been able, as a result of this conversion, to increase to a large extent their receipts, and to balance their accounts. In the same way the light railways with heavy traffic serving the large cities, and which have very severely felt the competition of the road, both by public and private services, have found in electrification, a needed and effective remedy by which to obtain cheaper operation, and to increase the speed and the number of the trains.

Another condition which becomes more and more essential for the well being and the growth of the light railways, serving as feeders to the great companies, is the use of all measures which may contribute to lessen the unfavourable consequences to the growth of the traffic, resulting from transhipment at junction stations. From this point of view, light railways serving regions which are not particularly hilly and difficult, ought in future to be built to standard gauge, and having such characteristics that common services may be organised with the main lines. The construction of narrow gauge railways can now be considered justifiable only in mountainous regions of little economic importance and situated at a distance from great centres of population; even in such a case, the possibility of creating systems capable of rational and harmonious development should be considered, with a certain degree of autonomy, as for example, by means of connections with sea or river ports, or by means of special economical and fast methods of transhipment.

In brief, the question of building new light railways in this period of the remarkable development of road motor traction, should be investigated with great care and prudence, in order to avoid setting up new transportation organisations of little flexibility and burdening the country with excessive capital charges, without procuring any direct or indirect corresponding advantages.

In this way, the investigations most recently made, by certain Italian experts and the conclusions to which they have come have led them to state that in future no new railway should be built, if the gross receipts expected were not at least 50 000 lires per km. (80 000 lires per mile).

After having broadly sketched the problem of the competition between railways and motors, we should be able to consider also the collaboration of these two great means of transport, in the interest of their mutual well being and of the development of the traffic. This however, is a problem which although capable of solution in a great number of ways, and under consideration by all great railway companies in the various countries, has however, less importance for light railways and especially for those recently built. When however, road motor services connect regularly and cheaply the railway stations to localities otherwise difficult of access, co-operation then becomes necessary and the railway companies end by finding therein a fresh source of traffic. In practice however, the problem is generally less simple than it would appear; in most cases it is difficult to stop the automobile service at the end of the railway line, especially if this is operated under economical conditions with a reduced service of trains running at low speed, and if the length of the line does not exceed 50 km. (31 miles) or even 100 km. (62 miles). Even when the public motor omnibus service does stop at the terminus station, hired cars, private cars, and motor lorries will always continue to menace the railways with the competition of road transport, a competition which is reflected by a loss of traffic. This important subject however, will be dealt with in detail under question XIII, and although it directly affects and to a large extent, the schemes for building new feeder railways, the object of the present report, we do not think it necessary to consider this point any further.

### II. — Building penetration railways in new countries.

We consider it desirable to make this first part of question XVII more concise by defining the meaning of the words « new countries ». It is obviously a question of those countries which for some reason or other are backward as regards railways, and are now obliged to consider the question of building a railway system which would meet the requirements of the different parts of the country, whether because these measures have already passed the first stage of growth, of modernisation, or of development, or because they have been waiting for the construction of a railway in order to carry out these changes.

In Europe, and in the two Americas, it can already be said that there are hardly any new countries if we give to this term the meaning indicated above. The sole exception that could be mentioned amongst the different countries of Europe is the kingdom of Albania : this country has not yet tackled the problem of communications by railway. The Americas and Australia are countries in which the question of constructing railways is being dealt with by one of our fellow reporters; so far as we are concerned our task consists in considering the situation in certain parts of Asia and especially in Africa.

At the last session of the Congress (London, 1925), our section adopted at the meeting of the 25 June, the following recommendation :

> From the technical and the commercial point of view, it is desirable that in neighbouring countries the main and secondary pioneer railways should adopt the same characteristics for their fixed installations and for their rolling stock.

This recommendation evidently desired to call attention to the advantages to be obtained from the standardisation of gauges and of their ultimate limitation to two or three types at the most, namely : standard gauge, narrow gauge, and very narrow gauge. It also, at the same time, drew attention to the advisableness of standardising the principal types of rails, and to the minimum weight to be used in the different cases, to the weight and dimensions of the sleepers, as well as to the utility of fixing for the three principal types of track, the minimum radius of the curves, and the steepest gradients on the line, so as to facilitate junctions, and to enable through traffic to be worked. Finally, the recommendation of our section implicitly requires a certain standardisation of the rolling stock, from the point of view of the loading gauge, of the maximum axle loading, etc., so as to facilitate exchanges between different countries or colonies, and to set up a closer working arrangement between one railway system and another.

This was a rational programme put before the railway engineers in a very interesting and attractive manner. In order however, to be the better able to realise the chances of the recommendation in question being carried out, and consequently its practical importance, the present situation in Asia, and especially in Africa (which can be considered as the main Continent of new countries) should be realised and the particular tendances of the various countries possessing colonies in this latter Continent should be briefly reviewed.

From the statistical information published in the « Universal Directory of Railway Officials » for 1928, the railways in Africa at the beginning of the year, were divided up as follows :

| | | | |
|---|---|---|---|
| Standard 1.435 m. (4 ft. 8 1/2 in.) | gauge railways | 6 950 km. | ( 4 320 miles). |
| 1.06 m. (3 ft.6 in.) | gauge railways | 34 000 » | (21 130 » ) |
| 1 m. (3 ft.-3 3/8 in.) | » » | 13 800 » | ( 8 575 » ) |
| 0.95 m. (3 ft.-1 3/8 in.) | » » | 900 » | ( 560 » ) |
| 0.76 m. (2 ft.-6 in.) | » » | 2 150 » | ( 1 340 » ) |
| 0.61 m. (2-foot) | » » | 1 600 » | ( 1 000 » ) |

This shows that whilst the wide gauge railways have adopted a uniform gauge (that is to say the standard gauge of 4 feet 8 1/2 inches, or 1.435 metres), the narrow gauge lines are divided into three distinct gauges although they differ but little one from the other : the two first (3 ft. 6 in., or 1.06 m. and one metre), reach a very large mileage; the third is that of the colonial railways in Italy (Tripoli, Cyrenaica, Erythrea, Somaliland) where a single type of track has been adopted for all the lines in operation, under construction, or projected. It should be noted that narrow gauge railways with which we are dealing, represent in Africa more than 85 % of the total length of lines being operated.

Finally, as regards the railways with a very narrow gauge, it will be noticed that the length of the line being operated with a gauge of 61 cm. (2 feet) is very nearly the same as that of those of a gauge of 76 cm. (2 ft. 6 in.); but their relatively small length and especially their character as a means of local communication, means that the international standardisation of gauges has in this case, only slight importance.

The question occupying us therefore concerns chiefly the narrow gauge railways, and the recommendation made at the London session should, practically speaking, apply to lines the gauge of which is between 95 cm. and 1.06 m. (3 ft. 1 3/8 in. and 3 ft. 6 in.).

Whilst on this subject, it should be pointed out that if the 1.06 m. gauge (which may be called the English gauge) is the most used, the metre gauge (which can be called the French track) has already reached such a development that it would today be very difficult to abandon it. In the same way the 95 cm. gauge whilst entirely confined to the Italian colonies, should be considered as a model already standardised, not only in these colonies, but also in Italy and in particular, on the two important secondary systems of the south, of Sicily and of Sardinia; and this standardisation not only applies to the gauge of the track, but also to the weight of the rails, and to a certain extent to the rolling stock. It would be almost impossible for Italy to abandon this gauge.

The problem of the standardisation of narrow gauge railways gives to rise to another consideration. In the interior of certain countries or colonies in Africa there are several types of narrow gauge lines. From the international point of view, the problem therefore becomes more complex, seeing that it has not been even possible to solve the matter within the limits of each country.

From this point of view, Egypt, Algeria, the Belgian Congo, etc., may be quoted as having within their boundaries, railway systems and lines of narrow gauge of different gauges a situation which it has not been considered necessary to change up to the present.

In the same way if we consider, for example, the countries and colonies in Africa along the Mediterranean and which owing to their geographical position nearer to Europe, and their general development more advanced, would appear to be more suitable for the standardisation proposed, we find the three gauges mentioned above for the narrow gauge lines, besides railways of standard gauge and lines of very narrow gauge. It would not really be possible to express in any definite way a preference for any one of these, nor to give any easy and reasonable solution of the problem.

If the problem considered in this way is one of great importance, it remains to see to what conclusions we can come if we consider it from the double point of view of trade and of tourist traffic.

As regards the commercial traffic, the commerce of the tropical countries in general, and especially the colonies, lies principally in the exchange of their products with Europe, and in the first line with the Mother country. The exchange of products between countries and neighbouring colonies in Africa represents in most cases a small part of the economic prosperity and of the traffic.

It should be added, that the system of colonial railways is almost everywhere formed by lines running out from the principal port towards the interior regions that have been developed and which are favourably situated for the exploitation of mines, the development of agriculture, and of stock raising.

As regards the tourist traffic, except in the case of certain railways, on which sleeping cars, restaurant cars, and Pullman cars run, and on certain railways of a special character (Trans-Saharian, etc.), the automobile is the preferred method of transport owing to its greater freedom of movement, and the facilities that it gives to visit sites of natural beauty, and the historical and artistic centres of the countries concerned.

It would appear then, that the examination of the situation in a practical manner would lead, as a whole, to conclusions rather less definite, than those adopted at the Congress of London. Without contesting the importance of the theoretical idea, of the standardisation of gauges for railways inside the boundaries of the different countries, it must be recognised that the present situation makes the practical solution of the problem extremely difficult if not impossible, and this on account of technical and financial reasons, as well as owing to the general lines of policy laid down by each Government (without mentioning political and military reasons); moreover, the rapid development of communications by automobile, and the canalisation of the traffic, brought into the ports by these, have had the result of appreciably reducing the drawback resulting from the existence of railways of different gauges at the same time.

What we have justly said about Africa, should be repeated, though in rather a different form, for Asia, where all the gauges mentioned in the case of Africa (except that of 0.95 cm.), are again found, and where there exist, in addition, railways of 5 ft.-6 in., and 5-foot gauges.

There are in Asia three countries the territories of which are so immense, that they can be consisered as continents, and consequently the problem of international communication by railway loses much of its importance; we are speaking of the Chinese Republic, the Union of Soviet Republics, and the Indian Empire. As for Japan, and the Dutch East Indies, their insular position lifts them out of this discussion.

Turkey in Asia cannot be considered as regards railways, as a new country. Siam, on the occasion of the inauguration and opening to operation of the great Rama VI bridge connecting the two railway systems of the north and south of the country, carried out the unification of the gauges of these two systems by adopting the metre gauge. This measure made it possible to organise common services for the 3 000 km. (1 865 miles) of railways in the country, the commerce and traffic of which should thereby develop rapidly, the more so as the railways of French Indo-China which lies to the east of Siam, have the same gauge of one metre.

As regards Persia, its actual railway system has a development of only 600 km. (373 miles). It is joined up near Tabriz with the Russian railways, and a scheme is being prepared for a new railway which crosses the whole country from north to south, leaving Besengarz on the Caspian Sea, and ending at Khormoussa on the Persian Gulf. This railway will serve the principal cities of the country: Tabriz, Teheran, Ispahan, Hamadan. As regards Afghanistan, the construction of a railway connecting the capital, Cabul, to the Indian frontier, is under consideration. It is obvious that these two countries, the railway system of which is very small, would be easily able to select the gauge or other characteristics of their line, so as to meet the needs of the country and above all the special conditions for international communication, by facilitating the necessary junctions with the railways of the neighbouring states, and thereby assuring the movement of trains without transhipment.

After this general review of the important question of the gauge of the railways in new countries, and of the conditions in which the standardisation of these gauges might be carried out, as well as the reasons acting against it, we will now examine in detail the characteristics of the railways in the different Italian colonies in Africa.

We may begin by reminding ourselves that these railways built since 1900 at various periods, have none the less very uniform features, and may be considered as a sufficiently rational solution as well as a uniform one, of the problem of the construction of penetration railways, used as a means for developing new countries. In order to avoid undue length and repetition, the guiding methods followed in setting out these means of communication were the same in different colonies; we will give the most detailed information on the railways in Tripoli, briefly dealing with those in Cyrenaica, Erythrea and Somaliland.

A. *Tripoli.* — Tripoli is above all an agricultural and pastoral country; the colonial activities therein are directed to developing the agricultural value of the country. It has an area of about 900 000 km² (347 500 sq. miles), the greatest part of which is not yet cultivated. At the present time the population is 550 000 natives; the country will have in the near future to support more than 200 000 colonists.

The railway is called upon to make economically possible the carrying out of the great work of colonisation, by making it easier to build and equip the farms, and in turn to transport cheaply and quickly the agricultural products to the consuming centres, and in the case of export, to the sea ports. To obtain this double objective, it is necessary, at least during the first period of transformation and development of the territory, that the rates should be as low as possible.

As a consequence, the policy to be adopted when building railways of this kind, should be to so organise the operation, that it is as economical as possible. It should therefore be the policy to spend as little as possible upon station buildings, and other structures : on the other hand, care should be taken to get a location as free from gradients as possible, to use curves of large radius, to avoid the use of too light rails, etc. In other terms, it is desirable that the solution of the problem should consist in a rational organisation, and a well thought out arrangement of the railway as a whole.

The principal port of the colony is Tripoli. Already fully equipped, it will become one of the best African ports on the Mediterranean, when the work now in hand is completed.

The railway system sets out in three directions from Tripoli, the capital of the colony, and a fine city now being well developed. The first line runs parallell with the western coast at a short distance from the sea and serves the rich oases and the great stretches of land now being cultivated, or property planted with timber by peasants from the Mother land. This railway, of a length of about 120 km. (75 miles) has now been carried as far as Zouara and its extension to the frontier of Tunis, has after due consideration been arranged; at this point it will be joined up with the railway system of the Regency. It is almost entirely on the level, and except for a small bridge 6 m. (19 ft. 8 1/4 in.) long, there are no structures. The waters of the rivers which flow intermittently (Uadiet) from a plateau situated about 100 km. (62 miles) away, do not get as far as the sea, or the railways, as they disperse in the plain, which is in this way flooded, and thereby fertilised.

The second line extends towards the interior through immense uncultivated plains and at present ends at Henscir-el-Abiad 83 km. (52 miles) from Tripoli, at the foot of the Garian plateau.

Beyond Henscir-el-Abiad the railway will have to climb the said plateau (750 m. [2 460 feet] high) with gradients not exceeding 25 mm. per m. (1 in 40), and curves of a minimum radius of 280 m. (14 chains), in order to reach Jeffren. A branch leaves this line near Assaba to end at Mizda, about 180 km. (112 miles) from Tripoli on the borders of a region almost a desert on the caravan route leading to Morzuk in the Fezzan.

The third line, now being worked to Tagiura (21 km. = 13 miles only) will be extended towards the east in order to connect Tripoli with the rich oases of Kussabat, Homs, and Misurata. The part of the railway already built and in use, has maximum gradients of 13 mm. per m. (1 in 77), and curves of a minimum radius of 130 m. (6 1/2 chains).

The track is laid with Vignoles rails, weighing 27.30 kgr. per linear metre (55 lb. per yard) laid on sleepers 2.30 m. (7 ft. 6 7/16 in.) long, in order to obtain a greater bearing surface in view of possible erosion in the ballast by the violent winds. The absence of destructive insects in the country makes it possible to use either wood or metal sleepers as desired. The number of sleepers is 16 per rail, and they are laid directly on the ground, the sandy and arid nature of the soil having made it unnecessary, without any real drawback, to use ballast. In order to protect embankments and cuttings against the erosive action of the wind storms which rage in the region, vegetation which takes root easily and grows vigorously, under the climateric and hydrological conditions of the country, has been planted.

The whole of these railways have been constructed with the most careful economy, although the rails are sufficiently heavy, the gradients reasonable, and the curves sufficiently large in radius. The cost of construction has been about 200 000 to 250 000 lires (320 000 to 400 000 lires per mile). The layout is such as to permit of a maximum speed of 40 to 45 km. (25 to 28 miles) per hour for heavy trains hauled by eight wheeled locomotives, and from 55 to 60 km. (34 to 37 miles) for light trains worked by petrol motor vehicles.

When building these railways, native labour was used on a large scale, the men being selected with care, and put under the control of workmen from the Mother country; the wages of the native labourers are about one third less, and their output as labourers and navvies was not very different from that of the whites.

So as to keep as small as possible the cost of earth work the movements of earth in the longitudinal direction was cut down to the minimum. The material from the cuts was laid alongside the road, and the embankments were formed from ballast pits alongside. This method is cheap, as there is as a rule no compensation to pay for the use of the ground, most of that used being the property of the State. When the line under construction runs through areas without roads the earth work was driven, forward, the sections of railway already laid temporarily being used to bring up materials and the men.

Buildings for the staff has been kept down in number and size, seeing that the natives would rather live under tents in their villages, and the white with their families in the towns. As a result, permanent way men are taken to their work and brought back by rail motors. The small stations as a rule, are not staffed to a large extent, the train staff being used to distribute tickets and to deal with the despatch of goods.

The staff attached to the operating side of the railway is on the average 290, or 1.26 men per km. (2.3 men per mile) of railway.

The average pay of an employee has been during 1927-1928 17.95 lires per day. The staff consists of Italians, and of natives; these latter numbering 180, are as a rule occupied in manual work.

There is a station master only at stations of a certain commercial importance, and he is charged at the same time with looking after the goods department. In localities where the level crossings are not protected, the movements of the trains are controlled by safety locking.

Since petrol rail motors have been used the passenger service has been completely separated from the goods service, the latter being assured by periodic trains usually run twice weekly on each line.

The budget of the system is as a rule balanced. The government of the colony covers the interest and amortisation charges of the capital expended in constructing these railways.

The results of the year 1927-1928 are as follows :

*Receipts :*

| | |
|---|---|
| Passengers . . . . . . . . | 1 111 749 lires |
| Parcels . . . . . . . . . | 113 788 » |
| Goods . . . . . . . . . . | 2 270 856 » |
| Miscellaneous . . . . . . . | 118 746 » |
| Total . . . . | 3 615 139 lires |

*Expenditure :*

| | |
|---|---|
| Management . . . . . . | 321 729 lires |
| Operation . . . . . . . . . | 468 389 » |
| Locomotive running . . . . . | 1 630 579 » |
| Track . . . . . . . . . . | 585 116 » |
| General charges . . . . . | 286 359 » |
| Miscellaneous charges . . . | 335 000 » |
| Total . . . . | 3 636 722 lires |

During the same period, 5 072 trains ran the following distances :

| | | |
|---|---|---|
| Passenger trains . | 155 335 km. | (96 522 miles) |
| Mixed trains . . | 54 403 » | (34 426 » ) |
| Goods trains . . | 25 142 » | (15 622 » ) |
| Total . . | 235 880 km. | (146 570 miles) |

These trains carried 5 897 first class passengers, 117 311 second class, and 69 080 third class, and 170 243 tons of merchandise.

As regards motive power there are 5 special rail motors which are 4 wheeled, and weigh 8.4 tons in running order; these motors are fitted with Fiat or Lancia (Turin) engines of 40 to 50 horse power. The maximum speed is 60 km. (37 miles) per hour, on straight level road. The trains are as a rule formed of a rail motor and one trailer. The consumption per train-kilometre is 245 gr. of petrol, and 5 gr. of lubricant (12.77 and 0.28 ounces per mile respectively). Each rail motor is driven by a single European employee. The cost price per train-kilometre is 2.5 lires (4.02 lires per train-mile), made up as follows :

| | Per train-kilometre. | Per train-mile. |
|---|---|---|
| Staff . . . . . . . . | 0.7 lire | 1.13 lire |
| Petrol . . . . . . . | 0.9 » | 1.45 » |
| Lubricant . . . . . | 0.15 » | 0.24 » |
| Maintenance and repairs (rail motor and railler) . . . . . . . . | 0.45 » | 0.72 » |
| Interest and amortisation . . . . . . | 0.3 » | 0.48 » |
| Total . . | 2.5 lires | 4.02 lires |

The goods and mixed trains are worked by 22 locomotives having 4, 6, or 8 wheels of the same type as those used on the secondary railways of Sicily (State Railways).

The rolling stock includes :

- 7 trailers for the rail motors,
- 8 first and 2nd class bogie carriages,
- 8 third class, parcels and post bogie vehicles.
- 300 wagons of various kinds,
- 38 tank wagons,
- 2 travelling cranes.

With steam traction, great difficulty has resulted from the extreme hardness (more than 60°) of the water available; the result is very heavy scale deposit in the boilers, with rapid corrosion of the firebox and tube plates. The remedy used has been to attach a tank wagon to the goods trains and mixed trains, so as to enable the locomotive to run longer distances without taking water, and so as to be able to use water from those wells at which the best water is available. Furthermore, soda is largely used when washing out boilers; this latter is done frequently with hot water.

We have mentioned above the construction of new railways or the extension of existing railways under construction or projected. This question is at the present time being investigated in connection with the possibilities of the growth of road motor traffic, and of joint rail and road transport, so that instead of the two methods being in competition, they should, as far as possible be made to supplement one another according to a properly considered programme.

As regards public services affecting more especially tourists, and in particular for visiting the superb ruins of Leptis Magna, and of Garian, these are covered by large modern luxury road coaches.

B. *Cyrenaica.* — This immense country (600 000 km² [211 670 sq. miles], 225 000 inhabitants) lies between Tripoli, Egypt, the desert and the sea, has two ports on the Mediterranean : Bengasi the capital, and Derna. The two railway lines at the present time in operation lead from Bengasi. The first runs from north to south towards the interior, and ends at Soluk; its length is 56 km. (35 miles). The second, about 108 km. (67 miles) long, runs towards the east, and today has got as far as the village of Barce. This latter line should be extended as far as Derna, in order to develop the lower plateau of Cyrenaica, and to facilitate visits to the celebrated ruins of ancient Cyrenea.

The Cyrenician railways have a 95-cm. (3 ft.-1 3/8 in.) gauge. The rails and the track in general are identical with those of the lines in Tripoli, the only difference being that as the country crossed is chiefly rocky, the sleepers, whether wood or steel, are laid on a ballasted bed. As regards buildings, the same types are used as in Tripoli, and meet the requirements of the country and the climate very well. The Cyrenician railways have no important structures, and in general are built on cheap lines.

None the less a heavy rail of ample strength has been used and the gradients and curves have been selected so as to make it easy and inexpensive to operate the system. Although from the orographic point of view this country is more broken, the radius of the curves is never less than 150 m. (7 1/2 chains), and the steepest gradients are 25 mm. per m. (1 in 40). The programme for the development of the system, provides for the construction of the line from Barce to Derna, about 210 km. (130 miles) long, mentioned above, and the line from Soluk to Agedalia which will have a length of 112 km. (70 miles).

In addition, good roads for motor lorries are also being built, and will make it possible to extend the services given by the railways by providing connections with public automobile services.

Cyrenaica, the population of which is less dense than that of Tripoli, has none the less recently seen its various traffics increase appreciably, and the year 1927-1928 has given the following results :

| | | |
|---|---|---|
| Operating receipts (passengers, parcels and goods). . | 2 840 129 | lires |
| Various receipts . . . . . | 31 084 | » |
| Repayment of expenses. . . | 151 359 | » |
| Total . . . | 3 022 572 | lires |

| *Expenditure :* | | |
|---|---|---|
| Management . . . . . . | 226 165 | lires |
| Operation . . . . . . . . | 372 391 | » |
| Rolling stock & locomotive running . . . . . . . . | 1 502 799 | » |
| Permanent way & works . . | 734 336 | » |
| General charges | | |
| Alteration of stock . . . . | 436 000 | » |
| Total . . . | 3 335 949 | lires |

The deficit of 333 337 lires, has been made good by the Government of the Colony.

The rolling stock includes 14 locomotives, 15 carriages, and 230 wagons. At the present moment, consideration is being given to an extended use of Diesel-hydraulic locomotives, the first examples of which are still under test; the economical results obtained so far, have been good.

C. *Erythrea.* — The first railway line of this colony was that between Massaoua-Ghinda and Asmara, open to operation on the 6 December 1911. Very bold in conception, and of considerable importance, this railway, which is only 120 km. (75 miles) long, leaves at sea level Massaoua to reach the capital of the colony, and the eastern gate of the Erythrean plateau, at an altitude of about 2 400 m. (7 874 feet). In the last section, that from Ghinda to Asmara, it is on almost a continuous gradient of 35 mm. per m. (1 in 29), with curves having 70 m. (3 1/2 chains) radius. As a result, it is neither easy nor cheap to operate.

Subsequently, the railway system has developed by building a number of lines, some of which were built for commercial reasons, whilst others were penetration railways; at the present time, there are 310 km. (193 miles) of line in operation and 102 km. (63 miles) under construction.

At the present time there is a proposal to extend the system as far as the frontier of El-Aghim. On all the lines recently built, the steepest gradients are 25 mm. per m. (1 in 40), and the minimum radius of curves 100 m. (5 chains).

The Erythrean railways have been built in a permanent manner, except for the Cheren-Agordat section where, in order to cross the rivers, the track has been directly laid on sand. The result is that the trains have to be stopped during the period of heavy rains which lasts about 90 days; the traffic does not however suffer very much from this as the caravans are very few in number at this season.

The financial results are increasingly satisfactory. The system is operated actively, and the management is able to provide for the renewal of the stock, etc., from its own funds.

The coefficient of operation is 65 %. The receipts from the years 1927-1928 amounted to 7 288 900 lires. The staff consists of about 800 employees, 91 of whom only coming from the Mother country. Native labour, moreover, costs much less than European labour.

The different types of rolling stock are built to the same design as those

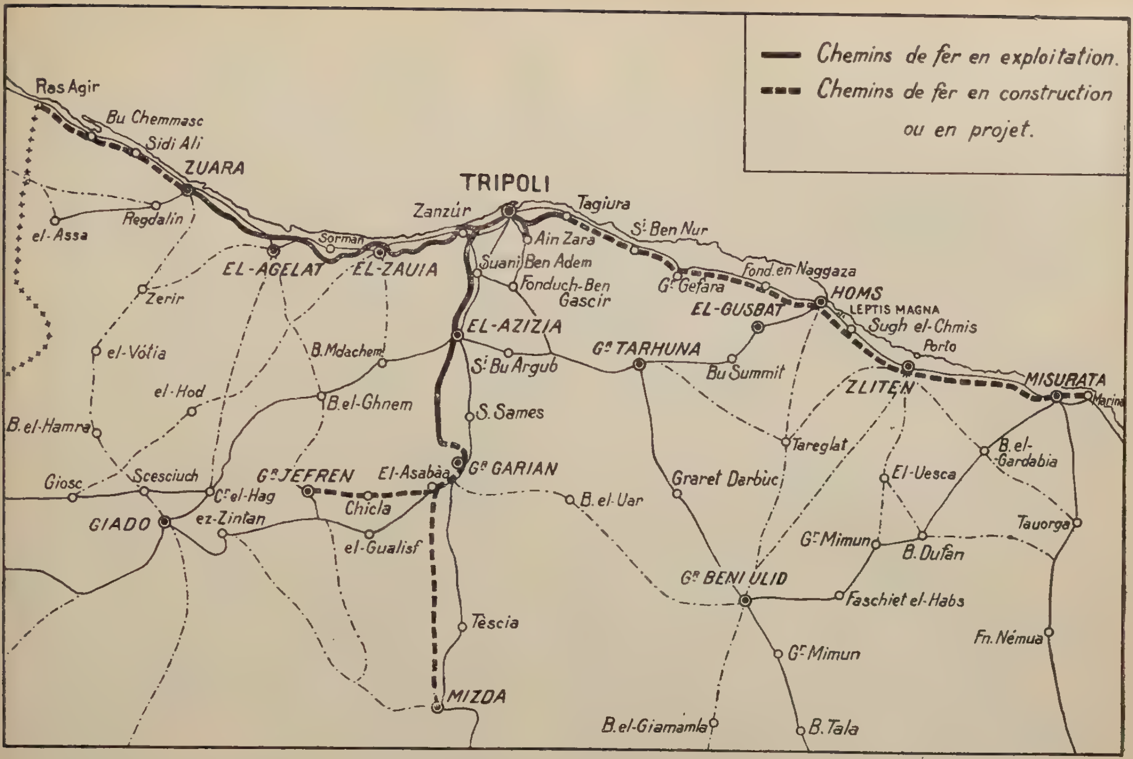

Fig. 1. — Tripoli. — Railway system.

*Explanation in right top corner (figs. 1 to 4):*

▬ Lines operated. ▬ ▬ ▬ ▬ Lines under construction or projected.

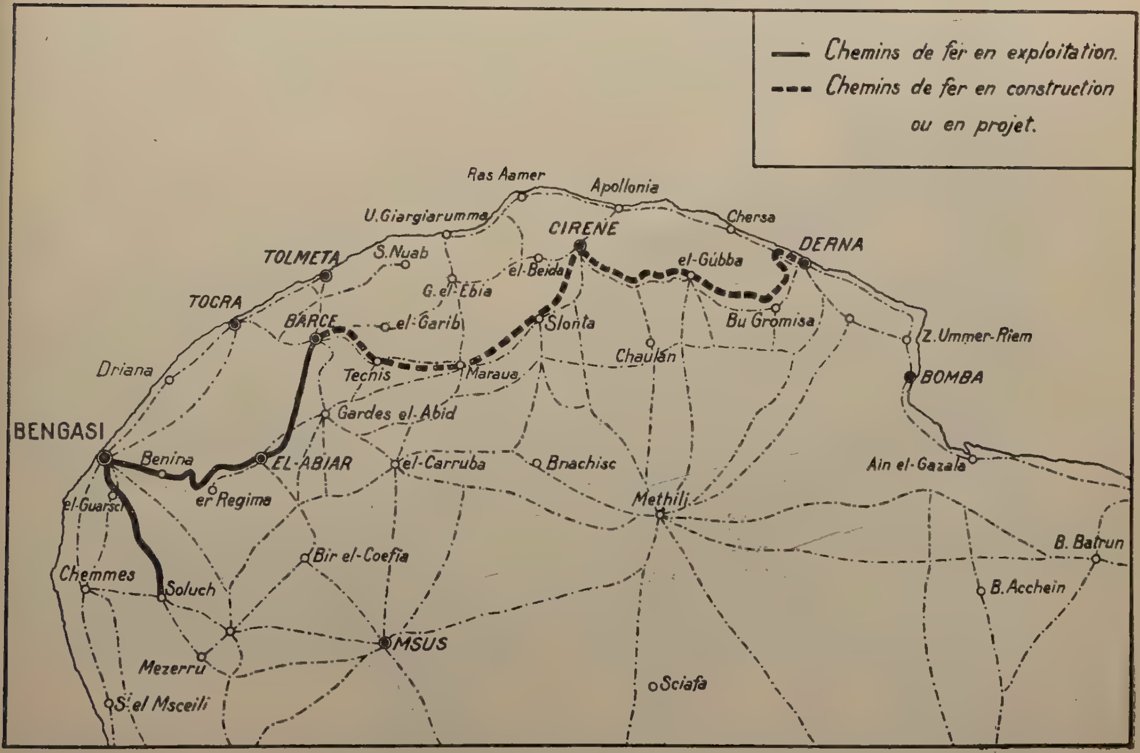

Fig. 2. — Cyrenaica. — Railway system.

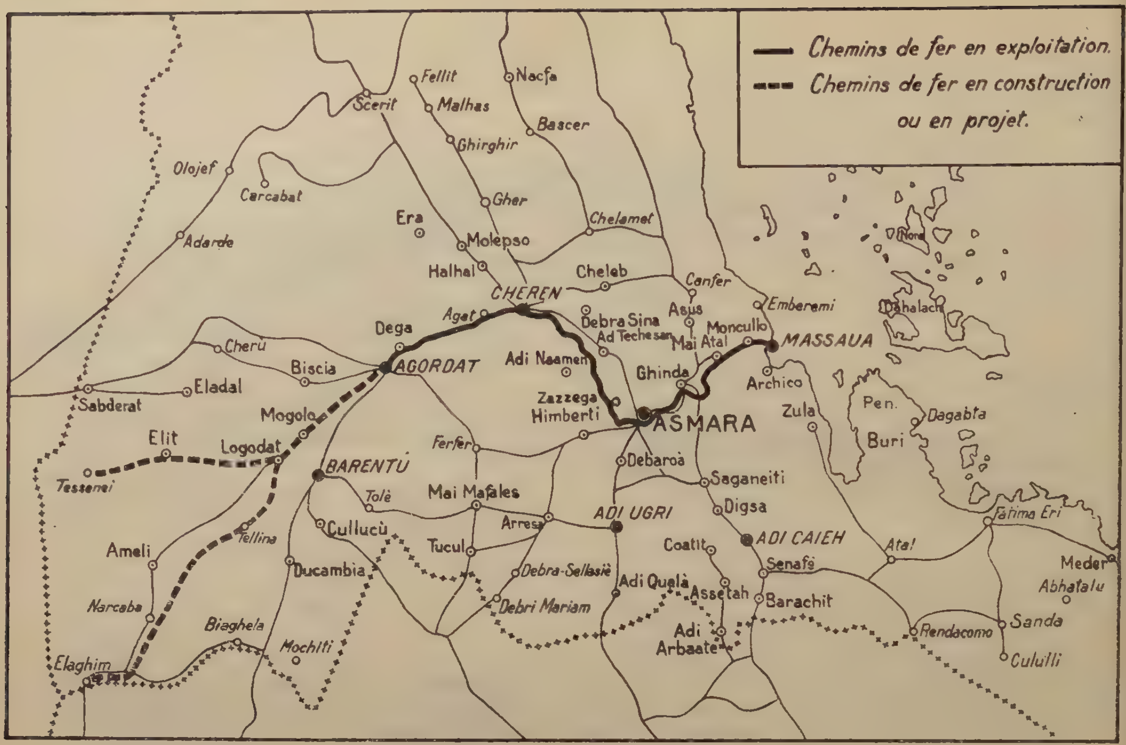

Fig. 3. — Erythrea. — Railway system.

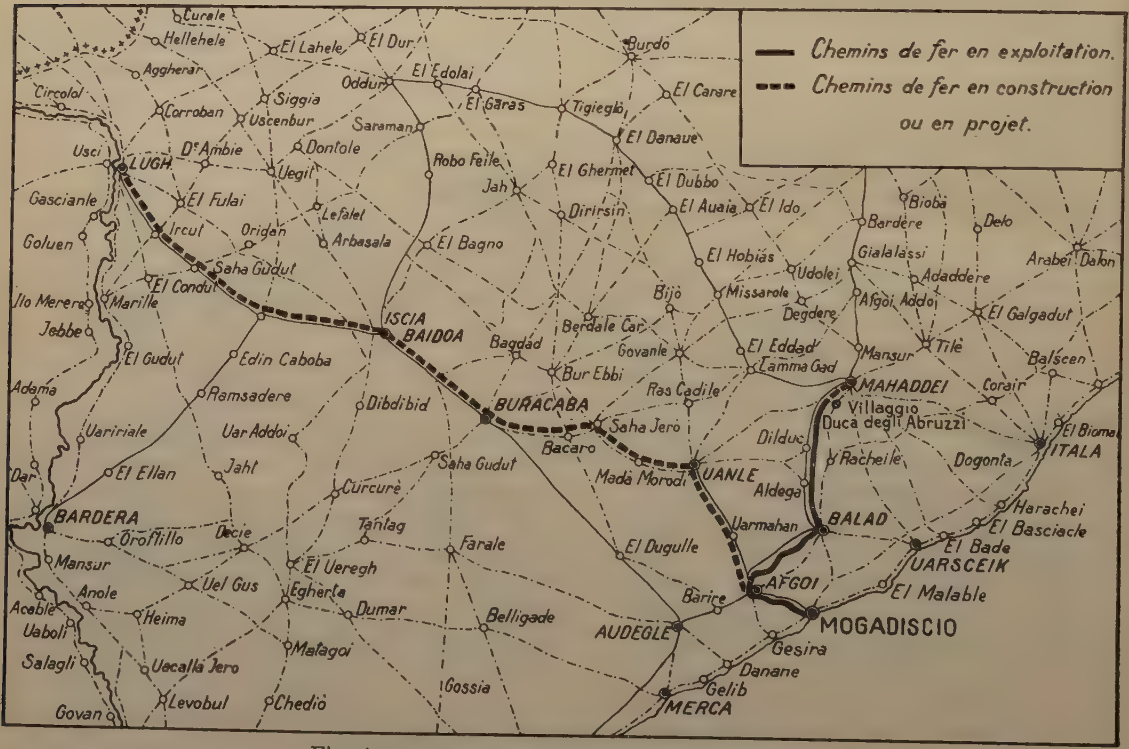

Fig. 4. — Italian Somaliland. — Railway system.

used on secondary railways of narrow gauge in Italy.

The management of the Erythrean railways has investigated during recent years the possibility of operating motor services in order to extend the area fed by its lines, and so as to profit by the traffic brought by feeder automobile services. An automobile service (Fiat 15Ter and 18BL Fiat and 31C Spa) is being operated between Agordat and Omager to carry passengers, parcels, post office parcels and goods, in connection with the railways. In addition, motor lorries do not attempt to compete with the railways, as regards merchandise traffic; in the same way automobile competition has only a very small effect upon the passenger traffic between Asmara and Massaoua.

The characteristics of the track are similar to those of the railways in Tripoli and Cyrenaica. The gauge is 95 cm. (3 ft. 1 3/8 in.) and the weight of rails is almost everywhere 27.30 kgr. (55 lb. per yard). Metal sleepers are used; wood sleepers cannot be used on account of the ants.

For new lines, either under construction, or projected, the curves are limited to 150 m. (7 1/2 chains) minimum radius, and the gradients to 10 mm. per m. (1 in 100).

The railway is operated by means of steam locomotives, there being 16 Mallet 0-4-0 + 0-4-0; 5 Klien Linder 0-8-0, and 10 less powerful engines. The rolling stock consists of 30 first, second, and third class carriages, with luggage lockers, and about 250 goods wagons.

The train service consists of three pairs of passenger trains weekly, between Asmara and Massaoua, and two between Asmara-Cheren and Agordat. All the goods trains are run as specials.

The question of feed water for the locomotive boilers is a very serious problem for the operating department, as in general the water from springs and wells is very hard. In order to overcome this difficulty, rain water is collected in reservoirs, and in addition waters are filtered or tank wagons used to carry supplies.

D. *Italian Somaliland.* — In this colony, as in those we have spoken of, railway communications have been designed in order to develop and bring into use those regions which are most advanced from an agricultural point of view, or which offer great possibilities of development. Up to the present there is one line in operation, that from Mogadiscio to Afgoi and the Duca degli Abruzzi village, 113 km. (70 miles) in length. This first line runs from the capital of the colony (which is at the same time its principal port) towards the interior, generally following the great Uebi-Scebeli river which runs through this region, now being developed for the growing of cotton, sugar and other tropical products.

A second line under consideration, will leave Adalei and run towards Lugh and the frontier of the Ethopian Empire.

The railways are of 95 cm. (3 ft.-1 3/8 in.) gauge, and are laid with Vignoles rails weighing as a rule 27.30 kgr. (55 lb. per yard), with metal sleepers which were originally laid direct on the ground, but are now laid on a good bed of ballast thereby giving greater stability to the track. The first section, that from Mogadiscio to Afgoi, which runs through the sand dunes, has gradients of 15 mm. per m. (1 in 67) and curves of 100 m. (20 chains) radius. The following sections are almost entirely on the level, and on the straight.

The lines are worked by steam traction. The staff is approximately 2 men per km. (3.2 men per mile). Native labour represents 93 % of the total staff. The pay of the natives is much lower than that of Europeans and their output about 50 % less than that of the latter.

The most difficult problem in working the line, is due to the extreme shortage of water along the railways, and the presence in the water of sulphate and chloride of calcium, and magnesium, thereby making it very hard. As a rule every train includes a tank wagon for supplying the locomotives and distributing water to the staff of the permanent way department. A water softening plant under construction should result in diminishing the difficulty resulting from the use of hard water.

The locomotive power includes 7 four- and six-wheeled locomotives, and the rolling stock 8 carriages, two tank wagons and 65 goods wagons. Although the budget is still in deficit, the financial results have improved very noticably during recent years. The receipts of the last working year amounted to a total of 1 591 527 lires.

In order to arrive at broad and valuable conclusions, it would have been necessary to make a comparison between the policy followed and the technical and financial results obtained in the colonies of Italy, and similar data relating to colonies of other countries.

The limits imposed on the enquiry into the question of penetration railways, would not allow this parallel to be established; it would however, be useful if it were considered again by the Congress when looking into this important question.

Furthermore any comparison with Egypt, cannot be made seeing that this country from a railway point of view, cannot be considered as a new country, and as its railways, especially those operated directly by the State, have a function and a reason very different from those of the European colonies, and can rather be compared with the railways of many of the countries of Europe.

As a whole we think however, that the question of the construction of railways in the Italian colonies has been well thought out and has been solved in a reasonable manner, the features and details of construction meeting the requirements of new countries which it is desired to develop, especially from an agricultural point of view, so as to make them of greater value to themselves and to the colonising country.

## CONCLUSIONS.

The conclusions to be drawn from the information, the data, and the observations given in the general part of this examination into the question of penetration railways, and in that dealing in particular with the Italian colonies, can, in our opinion be stated as follows :

*a*) Use in each colony of a uniform gauge, with the sole exception of railways dealing with particular kinds of traffic;

When there are no good reasons for adopting the standard gauge for certain lines, a gauge between 95 cm. and 1.06 m. (3 ft. 1 3/8 in. and 3 ft. 6 in.) appears desirable;

*b*) Use of a single type of rail of ample strength. The 25 to 30-kgr. per metre (50.4 to 60.5 lb. per yard) rail appears, for lines having the gauge given above, the most useful and the most suitable for ordinary operation purposes;

*c*) The necessity for observing when building new colonial railways, the principle of rigorous economy whilst adopting in the proposals, layouts which make it possible to operate the line easily and cheaply, and at high speeds, so as to meet modern requirements and meet the possible competition of motor vehicles;

*d*) Use of coloured labour to the greatest possible extent allowed by the aptitude and the possibilities of recruitment of the natives;

*e*) Careful study of the most suitable methods of traction either in order to lessen the cost of fuel, or to be able to run light, fast trains, and to separate the passenger service from the goods, or, to overcome the difficulty found in many regions with regard to locomotive water;

*f*) Use of moderate rates, both for passengers and goods, as regards the latter, to give the rate the simplest possible form, so as to attract readily traffic from the native population, and thereby better compete with the caravans, which are too slow and less safe;

*g*) To consider close working arrangements between the railway and public motor services, in order to facilitate the flow of traffic to the different despatching, or exchange points on the railways and to lessen the effects of competition.

In connection with this important question it should be added that the motor car, which is already of very great importance in most of the colonies, thanks to its great mobility, to its ability to overcome the difficulty of running through desert country and also as a result of its economical advantages, and which does not involve locking up of a large amount of original capital, must be considered in the colonies in particular as the vehicle of the future. It would then be almost absurd to endeavour to fight by any artificial methods its free and proper development and it is already desirable to limit oneself to taking such steps as will bring the two methods of transport together rendering them complimentary one to the other as much as possible.

The caravan traffic is bound to decline rapidly; it will be possible to create a very much greater traffic by developing the new countries in particular from the agricultural point of view, and by intensifying the commercial relations between the colony and the Mother country. It is upon this point that railways and road motor vehicles should concentrate their efforts, possibly by a general agreement, and, in any case, by following the very clear, rational, and up to date lines laid down by the Government;

*h*) When constructing new colonial railways, the locations in tropical regions should be studied with a view to serving the greatest possible number of inhabited centres, even if this should result in the line being of greater length. Care should also be taken to avoid great lengths where water is scarce, not only because water is essential for the railway itself, but also, and more especially because where there is no water it is almost impossible to think of developing the agriculture, and it is consequently an illusion to expect new centres of population which might develop the traffic;

*i*) Finally except in very special cases there does not seem to be any further reason for recommending, when constructing new railways, the use of very narrow gauges (less for example than 95 cm. [3 ft. 1 3/8 in.]) and a very light permanent way; in fact such railways which are rather in the nature of Decauville track are very useful for private undertakings for developing forests or mines, etc., but do not meet the needs of a regular and full operation with the fast movement of passengers such as is required in the colonies. In the case of traffic of little quantity, it is always better to organise automobile and lorry services.

### III. — Construction of feeder railways in all countries.

Before dealing with this question, it will be as well, as we did in the first case, to define the bearing thereof.

Feeder railways are, by definition, light railways which receive traffic of a limited area and hand over a part to the great railways for its final destination. We find ourselves in the presence of the conditions pointed out in the introduction of this report. It is a question of railways which during a long period after the almost complete disappearance of coaches and carriers had a sort of monopoly in dealing with local goods traffic, and the conveyance of passengers. The great majority of these railways have felt for some time serious competition from motor transport which offered to the public certain advantages previously unknown; these vehicles collect the goods at their point of despatch or of production, such as works, warehouse, farm, etc., and carries them quickly and without transhipment to their destination.

Faced with this situation the gravity of which, far from being temporary, appears to become more and more serious, two problems presented themselves upon which the management of the railways had to decide; they can be stated as follows :

1. Steps to be taken to save the existing railways from a complete decline and to ensure to this method of transport the greater part of the traffic of the area served in conjunction with automobile transport and with motor lorry services carried out by industrial organisations or by private firms. These road transport undertakings should retain as far as possible the character of auxiliary services or feeders;

2. Technical and economical characteristics to be adopted when building new secondary railways in order to ensure as far as possible their continued well being, their usefulness and their capability of collecting traffic of all kinds and carry it to the great railways system.

We will consider further on in detail the replies of the different railway companies to the questionnaire sent them; these replies give information upon the general policy followed upon this matter in each country and the results obtained. But first of all it would perhaps be useful to look at the problem as a whole.

It is certain in future that if, on the one hand the management of railways insists when it is designing and carrying out the alterations and modernisation to the railways, that these should be able to meet competition with the motor services and to regain a part of the traffic that has been transferred or lost, there are on the other hand many engineers who foretell the end of the usefulness and of the necessity of many secondary railways and their inevitable disappearance as means of public conveyance.

A pressure in this sense is exercised with all the immense power of its means by the world wide automobile industry, which, as its almost fantastic development continues, seeks today to remove all the barriers which oppose the extension of the new method of transport in its numerous applications, and in all countries including those farthest afield and those most backward. In fact a demand is made with much insistance, that the old light railways built under conditions now considered as out of date and operated in a manner which no longer meets the needs of modern populations and of the present day traffic should be abandoned, and that in certain cases the modest although very necessary functions that have so far been carried out by these railways, should be transferred to the motor vehicle.

As in all conflicts between divergent or definitely opposed movements which hide great financial interests, there is evidently exaggeration on both sides, and it is in the middle course that the most rational solution from the double point of view of technique and economy is to be found.

The existing light railways should be considered as a form of wealth created by our ancestors, and of great utility for the various countries and before allowing them to fall out of service we should consider whether they cannot be brought up to date so as to extend their life and utility, even if this occurs in parallel to the development of the motor.

It is only when such investigation leads to the clear and indisputable conclusion that the role of any particular line is really finished, that the closing of the railway should be decided. This step has already been taken in many countries in isolated cases, it is true, (and especially by those where the ordinary roads have been developed and modernised most, and where as a result the motor vehicle has been most developed), but it could take more considerable and more disquieting proportions.

None the less it may be presumed that many railways, probably the majority, will continue to live and contribute, alongside the motor and other means of communication, to the growth of traffic in the different regions. We may remember in fact that to transport great numbers of passengers (for example the workmen and employees living in the suburbs of great cities, who make twice daily the journey between their places of residence and their work or office) and for the heavy traffic of goods of low value (generally those in the lowest classification of the railways) the railways still has appreciable advantages over motor transport.

What is, however, incontestable, is that the light railways operated under out of date conditions with too low train speeds and with services the infrequency of which is insufficient to meet modern requirements, with a rolling stock entirely inadequate for present needs, should be considered as anachronism, and as organisations to be condemned.

As for new light railways, unless they are to serve as communications for reasons of a national character (that is to develop poor and backward regions) it is necessary, under the present conditions of competition, to take great care when approving their construction in cases where it is not possible to count upon sufficient guarantees as to their vitality and when one is not confronted by the real needs of the region to be served.

We will give clear and detailed conclusions on the characteristics mentioned above after having dealt with the information supplied by a certain number of railways; we would remark, however, that the growth of the communications with which we are dealing and the construction of new lines are destined to be slowed down considerably on the one side because of the competition of road motors, with their great freedom of movement and the facilities they offer to the public, and, on the other, in view of the very great cost of construction and of the locking up of the large amount of capital which results.

### Replies to the questionnaire sent to the railway administrations.

A. Egypt. — The Egyptian State Railways form a system with a uniform gauge, the standard. This gauge has also been used for secondary lines in order to facilitate the movement of goods on to the principal lines and to develop through traffic in general. Until November 1926 the line from Louqsor to Assouan had a 3 ft. 6 in. gauge, but, for reasons that we have just indicated, it has been altered to standard gauge. Transshipment is therefore not necessary except in the cases of certain stations with light railways operated by private companies; up to the present no use has been made under such cases of any special means for facilitating transshipment.

The Egyptian system uses 37 to 47 kgr. per m. (74.6 to 94.7 lb. per yard) rails. This latter profile can be considered as the standard adopted by the administration and this weight of rail is now used when relaying. The sleepers are generally laid on gravel which is found everywhere in the country; good ballast is also used, although this is much more rare.

The sleepers are as a rule of wood, usually pine, but in some cases steel sleepers are also in use. At the present time the State is building 70 km. (43 miles) of new railways and is considering the construction of another 400 km. (250 miles). In addition, the doubling of the track is being carried out on 150 km. (93 miles). The new railways have the same characteristics as those mentioned above.

The State Railways (light railways included) are worked by steam locomotives and the speed of the trains reaches 60 km. (37 miles).

The competition by motor transport is very serious for short distances. A scheme for setting up through services between the railways and the road motor services is being considered but up to the present has not been put into force.

B. Switzerland. — The whole of the railways both main line and secondary lines of the State are of standard gauge, with the exception of the Brüning line, which is metre gauge. This line connects Lucerne with Interlaken-East and has a length of 52 km. (32.3 miles), 9 283 m. (5.77 miles) of which is rack railway. The Brüning Railway was built to narrow gauge because it runs through mountainous country involving great differences of level, and also because it is used more especially by tourists. The goods traffic passing over this railway represents a very small tonnage.

Traffic by complete loads or from intermediate stations, is carried out on the adhesion sections by transporter trucks; these cannot pass over the rack sections. The other goods are transshipped at Lucerne or at Interlaken.

Switzerland possesses a great number of secondary railways which are feeder railways which belong to private companies, but their methods of construction and operation are so different that it is not easy to draw any uniform conclusions from them as regards the conditions of secondary railways in all countries.

Up to the present the Swiss Federal Railways have not had to build more than 14 km. (8.7 miles) of this sort of line, but as in this case it is merely a question of economic interests, and as the receipts are not sufficient to cover the operating expenses, the construction of this line has been deferred and instead a service of motor lorries for goods and of motor buses for passengers at railway rates has been organised. This motor service is carried out by the Swiss Post Office which already possesses a large organisation for carrying passengers by motor coaches in districts not served by the railway, as well as over many Alpine routes.

The motor services organised by private undertakings compete very seriously with the Swiss Federal Railways, both as regards the main lines and the secondary lines. The deficit which has resulted has to be carried by the railway administration. No line of the system has had to be closed however as a result.

*Rhætian Railway :* The Rhætian Railway Company operates a system of moutain lines of metre gauge having a length of 277 km. (172 miles). It is building 85 km. (52.8 miles) of new line, the concession for which has been given it. The metre gauge was selected for economic reasons and because of the technical difficulties met with in the districts run through. Transhipment at the junction station with the main railway system is easly done and does not react adversely on the traffic. Transporter trucks have been adopted for the full loads for the main railway but this method can only be used for short distances and does not show any appreciable saving. The operation of the railways has given sufficient return on the capital; in fact the budget balances.

The trains are worked by electric traction and their speed varies from 35 to 50 km. (22 to 31 miles) an hour. The track and the rolling stock is of the usual type. The Company is considering the question of building other railways on the same lines. It does not report any serious competition by road motors. There exists in fact a cantonal law which prevents heavy lorries and public services from competing with the railways.

C. Norway. — The Norwegian State System does not as rule possess any lines with heavy traffic; in this way the administration has not found it necessary to make any very definite distinctions between main and secondary railways. The narrow gauge lines of old construction have in fact been rebuilt and converted to standard gauge. At the present time the State system includes only two lines of 1.067 m. (3 ft.-6 in.) gauge, with a total lengh of 465 km. (289 miles) excluding three short lines quite isolated.

In the latter cases the railways carry out the transhipping without any supplementary charge being required from the users, so that in spite of the inconvenience of this operation it does not have any too serious adverse effects upon the growth of goods traffic. It should be noted, however, that at one point, at Drammen, the change has had the result of a very marked falling off of passenger traffic in favour of steamship lines and motor services running in competition.

The competition of road motor services has a very serious influence upon the traffic of the light railways. Joint services have been set up between the State Railways and a certain number of public road motor services. The State Railways themselves operate certain public automobile services; these are placed under the management of the head of the division concerned. No railway line has been closed as a result of road motor competition.

D. Sweden. — The Swedish State Railways are not divided into main and secondary lines. But if we include amongst secondary railways all those lines joined up to main trunk lines, or which leave a main line, to connect a district to it, the State Railways include 1 319 km. (820 miles) of secondary lines, now in operation and 300 km. (186.4 miles) under construction or projected. Following the practice of the main line as well as that of the private railway companies, the most important of the secondary lines in question are of 4 ft.-8 1/2 in. (standard) gauge as it has been considered that from both the technical and economical point of view it would be undesirable to use a different gauge for the secondary railways.

These latter lines have rails weighing from 27 to 34 kgr. per m. (54.4 to 68.5 lb. per yard) with wooden sleepers laid in gravel. They are operated by steam traction; the trains run at a maximum speed of 60 km. (37 miles) per hour. The rolling stock used is practically the same as that on the main lines.

New lines are under consideration as the Swedish railway system is still relatively little developed.

At the present time no simplification in the organisation of the services on the secondary lines has been considered. It has however been decided to adopt everywhere such simplifications as can be introduced without affecting the safe running of the trains.

Road motor competition over short distances exists in Sweden and concerns in particular passenger traffic as well as the transport of light goods of small volume.

The State Railways have already organised four road motor services which they operate directly.

Up to the present no railway line has been closed as a result of the competition of road motor services.

The *Västergötland-Göteborg Railway* (Göteborg), has 380 km. (236 miles) of standard gauge, and 168 km. (104.4 miles) of narrow gauge line in operation.

On the former the maximum gradients are 16 mm. per m. (1 in 63), and the minimum radius of the curves is 300 m. (15 chains) on the running road, and 200 m. (10 chains) near stations. No new line is either under construction or projected.

The operation of these lines is by steam, with 4-4-0 locomotives for passenger trains, and 2-8-0 for goods trains. The maximum running speed is 60 km. (37 miles) per hour; the ordinary working speed varies between 30 and 45 km. (18.6 to 28 miles).

In order to reduce operating costs the Company has tested locomotives driven by one man, rail motor coaches, and simplifications in the methods of despatching goods. At the present time the staff represents 1.64 men per km. (2.64 men per mile) of line. The Company experiences great difficulties through snow and low temperatures. Snow ploughs and protective devices against the cold are in use.

The competition of road motor services has had appreciable effect upon the receipts. The Company operates a line of motor omnibuses connecting with the trains and is considering cooperation with motor lorry services for the carriage of goods.

The narrow gauge (89 cm. = 2 ft. 11 in.) lines have a total length of 168 km. (104.4 miles). This gauge was adopted for economic reasons. The rails weigh 25 kgr. per m. (50.4 lb. per yard), and are laid on wooden sleepers carried on gravel ballast.

The trains are hauled by steam locomotives: their maximum speed is 45 km. (28 miles) per hour. The transhipment of goods at the junction with the main line exercises an unfavourable influence upon the traffic.

The competition of road motor services is not yet sufficiently developed to upset the operating results of the railways.

The Company so far, is not considering the setting up of connecting services by means of motor omnibuses.

E. Denmark. — The whole of the State Railways including feeder lines was built to standard gauge. The lines carrying little traffic are laid with Vignoles rails weighing 22.5 to 32 kgr. per linear metre (45.3 to 64.5 lb. per yard). In the same way, as the other secondary lines, they have been designed to allow vehicles having a maximum axle load of 12 to 13 metric (11.8 to 12.8 English) tons to circulate freely.

F. Finland. — The Finnish State Railways do not possess any penetration line of railway either in operation or under construction.

G. Kingdom of the Serbes, Croates and Slovenes. — The secondary railways of the Kingdom of the Serbes, Croates and Slovenes, was formed by the amalgamation of five different systems which belonged, before the Balkan War and the Great War, to five different Railway Administrations: Serbian, Turkish, Austrian, Hungarian, and Bosno-Herzegovinian. Owing to their different origins, the secondary lines have developed in different ways.

The position of the secondary lines at the end of the year 1928 was as follows:

*Railways operated by the State:*

*a*) Secondary lines of standard gauge (light and local), 1 700 km. (1 050 miles) belonging to the State, 2 800 km. (1 740 miles) of private property; the whole 4 500 km. (2 796 miles).

*b*) Lines of 76 cm. (2 ft.-6 in.) gauge: 1 743 km. (1 083 miles) belonging to the State, and 107 km. (66.5 miles) belonging to private companies; together 1 850 km. (1 149.5 miles).

*c*) Lines of 60 cm. (1 ft.-11 5/8 in.) gauge belonging to the State : 500 km. (311 miles).

Total length of the system operated by the State : 6 850 km. (4 256.5 miles).

*Railways operated by Companies.*

Secondary lines.

*a*) Standard gauge, belonging to the State : 16 km. (10 miles).

*b*) Metre gauge belonging to private companies : 186 km. (115.6 miles).

*c*) 76 cm. (2 ft.-6 in.) gauge, 525 km. (326.3 miles) belonging to the State and 175 km. (108.7 miles) to private companies; together 700 km. (435 miles).

*d*) 60 cm. (1 ft.-11 5/8 in.) gauge belonging to the State: 21 km. (13 miles). Total 920 km. (571.6 miles).

The light or secondary railway system (whether standard gauge or narrow) is therefore 7 770 km. (4 828 miles) and represents 77 % of the whole railway system of the country, the present length of which is 10 100 km. (6 276 miles).

As this system is not sufficient to meet the requirements of the country, new 76-cm. (2 ft.-6 in.) gauge lines are being laid out and built in Serbia, Bosnia, Herzegovinia, and Montenegro, countries which are mountainous and in which industry is still relatively little developed.

In the other provinces to the north of the Save and the Danube, all new secondary light railways will be built to standard gauge.

The transhipment between lines of different gauges causes some operating difficulties.

Transhipping at the junction stations results as a rule in a delay of 16 hours, and this reduces the commercial speed.

This difficulty is appreciable as regards the traffic on lines of narrow gauge carrying as a rule much material for the standard gauge lines. So far, transhipment tracks have not been adopted.

The railways are operated by means of steam locomotives.

The running speed of passenger trains on the secondary lines varies between 30 and 40 km. (18.6 to 25 miles).

The types of rails used on these lines vary widely.

On the 76 cm. (2 ft.-6 in.) gauge railways, the weights adopted are as follows in kgr. per metre: 13.75, 14.25, 17.69, 17.80, 19.91, 21.8 and 22.1 (27.72, 28.73, 35.66, 35.88, 40.14, 43.94 and 44.55 lb. per yard). On the 60 cm. (1 ft.-11 5/8 in.) gauge lines, 6, 8 and

9.2 kgr. per m. (12.1, 16.1 and 18.5 lb. per yard) rails are used.

The sleepers are in oak or in creosoted elm, the dimensions being fixed at 2.30 m. × 14 cm. × 22 cm. (7 ft. 7 9/16 in. × 5 1/2 in. × 8 11/16 in.) for the standard gauge secondary lines, and at 1.70 m. × 14 cm. × 22 cm. (5 ft. 7 in. × 5 1/2 in. × 8 11/16 in.) for 76 cm. (2 ft.-6 in.) gauge lines.

Metal sleepers are used on the 76-cm. and rack lines, and on the 60-cm. narrow gauge lines.

Road motor competition has been felt especially near the great cities and in local traffic, but not to a very great extent as motor transport is still in the development stage.

So far there are no motor omnibus services running in connection with the railways.

H. Czecho - Slovakian Republic. — The local light railways are as a rule of standard gauge with steam locomotives and have gradients of 30 mm. per metre (1 in 33) as a maximum with curves of a radius as small as 150 m. (7 1/2 chains). The speed of the trains does not exceed 30 km. (18.6 miles) per hour. The extent of this railway is as follows:

*a*) Light local railways belonging to the State and operated by it : 3 515 km. (2 184.2 miles).

*b*) Private local light railways operated by the State: 1 809 km. (1 124.1 miles).

*c*) Private local light railways operated by Companies : 249 km. (154.7 miles).

The State system also includes a further 293 km. (182 miles) of 76 cm. (2 ft. 6 in.), 10 km. (6.2 miles) of 75 cm. (2 ft. 5 1/2 in.), and 48 km. (29.8 miles) of one metre.

The Companies operate 61 km. (37.9 miles of 76 cm. (2 ft. 6 in.), 14 km. (8.7 miles) of 70 cm. (2 ft. 3 1/2 in.), and 35 km. (21.7 miles) of 1 metre.

On all the narrow gauge railways the transhipment due to the differences of gauge form a serious obstacle to fast and regular transport. On all the narrow gauge lines in the former Austrian territory (75-cm. [2 ft.-5 1/2 in.] gauge), the State uses transporter wagons by means of which standard gauge wagons can be worked over the local railway lines.

On such lines of the former Hungarian territory such trucks have not been introduced, and it is consequently necessary to tranship at the junction station. This transhipment is either undertaken by a contractor at a standard fixed price, or is carried out by the Railway itself.

The Companies do not make use of transporter wagons and tranship the whole of the consignments at the tranship stations.

Electric traction has so far only been adopted on the following lines belonging to the State:

1. Certlov-Lipno;
2. Trenc-Teplà, Trenc-Teplice Kúpele,

and on the private lines;

3. Bratislava-Hainburk;
4. Mor-Ostrava-Karvinná;
5. Moravian local railways;
6. Silesian railways;
7. Tatras local railway.

Rail motor coaches fitted with internal combustion motors have recently been introduced on a whole series of local light railways either by the State or by the Compagnies for passenger traffic.

In the case of standard gauge lines the weight of rails at present used varies from 26.15 to 30.65 kgr. per m. (52.7 to 61.8 lb. per yard).

For metre-gauge lines, rails weighing 22.05 kgr. per m. (44.4 lb. per yard) are used.

For 76-cm. (2 ft.-6 in.) lines, the weight is 17.8 kgr. per m. (35.9 lb. per yard) and therefore is lighter.

The ballast is composed of river gravel, sand, ashes, cinders, and sometimes even rammed earth.

Wooden sleepers are used mostly of soft pine; creosoted wood sleepers are now also being used.

At the present time the construction of new light railways is considered as impossible owing to the high cost of construction.

The effect of motor competition upon the system is appreciable. Specially in the carriage of passengers, motor competition is very serious owing to the characteristic feature of a mobile vehicle which is not obliged to follow a fixed route, and which gives direct connection between the centres of the different cities.

This effect is growing in the case of local light railways where the relatively light traffic and the modest commercial speed of the trains facilitates the growth of motor competition. In the case of goods traffic motor competition has only been felt for distances up to about 50 km. (31 miles).

An endeavour is being made to meet this competition by accelerating the trains.

In Czecho-Slovakia no real joint service between the railways and the motor companies has been organised. On the other hand motor services for public transport which connect different sections of the Railway and prevent private competition, are being operated in cases where this competition was particularly serious and was taking from the railways a too great proportion of the passenger traffic.

In the same way goods motor services are being established and that on the line Furna-Rozuava will be opened to operation during the present year.

In the local light railways domain, the use of motor vehicles has shown itself a useful method by which to compete with road motors. The relatively low cost of operating road motor coaches makes it possible to increase the service as well as to arrange the commercial speed. The type of light railway motor coach weighing about 8 tons with a trailer weighing 5 tons, a type already in use on forty lines most of which are secondary, has shown itself to be particularly suitable.

Although the introduction of this motor omnibus on the railway has been carried out on a large scale only since the middle of 1928, the results have already shown themselves sufficiently satisfactory, and in particular a marked reduction in private competition has been observed.

Up to date none of the secondary railways have been closed down, but it is not considered either economical or opportune to build under present conditions new feeder lines of railways, unless it is in exceptional cases such as the appearance of a new industry requiring to import or export large quantities of products coming from the main railway systems or destined therefor.

I. RUMANIA. — The secondary system of railways of the State includes 3 100 km. (1 926 miles) of line in operation. There are no Railways of this type under construction. The gauge varies from 60 cm. to 1.435 m. (1 ft. 11 5/8 in. to 4 ft. 8 1/2 in.) (standard gauge). The difference which exists between gauges is a result of the different origins of the lines which formerly belonged to Austria, to Hungary and to Russia.

The rails vary in weight from 7 to 30 kgr. per linear metre (14.1 to 60.5 lb. per yard).

They are laid on wooden sleepers on gravel ballast.

These lines are operated by steam locomotives the maximum speed of which is 20 to 50 km. (12.4 to 31 miles) per hour.

At the junction stations with the main railway systems transhipment is almost always necessary, and as a result there are serious drawbacks which result in an increase cost and a reduction of the traffic. This work is carried out at tranship platforms in the junction stations.

The receipts are not always sufficient to balance the expenditure and the accounts are then balanced by drawing on the revenues of the other lines. If the deficit reaches excessive proportions the line is closed to operation.

The influence of road motor competition has been insignificant so far. It is only now beginning to be felt in such districts where the roads are good. The Administration of the State Railways has not organised through services in conjunction with motor omnibuses.

Certain lines of the system have already been closed as a result of the lack of traffic and of the loss in working.

It appears that the Administration is considering the conversion of part of the secondary Railways by adopting the standard gauge in order to obviate transhipment and to improve the gradients so as to reduce the cost of working.

J. Bulgaria. — The secondary railway system of Bulgaria which is entirely operated by the State has a length of 1 058 km (657.5 miles), 561 km. (348.6 miles) of standard gauge, 138 km. (85. 7 miles) of 760 mm. (2 ft.-6 in.) gauge and 736 km. (457.3 miles) of 600-mm. (1 ft.-11 5/8 in.) gauge.

The secondary railways under construction, or projected are of standard gauge or of 760-mm. (2 ft.-6 in) gauge, and have a total length of 1 300 km. (808 miles).

Provision has been made for the narrow gauge lines (600 mm.) generally built during the European War to be gradually replaced by standard gauge lines. A transhipment at the junction-stations from the secondary narrow gauge lines to the main lines, is obviously a difficulty, but it is not too serious and the effect upon the goods traffic is very light. The transhipment is carried out so far by the ordinary methods.

The secondary light railway system is worked by steam locomotives.

The running speed for the different sorts of passenger trains on the standard gauge lines varies between 40 and 65 km. (25 and 40 miles) and upon the narrow gauge lines between 15 and 25 km. (9.3 and 15.5 miles).

The weight of the rails is 31 kgr. (62.5 lb. per yard) on the standard gauge lines, 20 kgr. (40.3 lb. per yard) on the 760-mm. (2 ft.-6 in.) lines, and 9.5 kgr.(19.1 lb. per yard) on the 600-mm. (1 ft. 11 5/8 in.) lines.

The ballast is either river gravel or broken stone. Wood sleepers are used.

As a rule the secondary lines do not pay their way, and the general budget on the railways of the country have to meet the deficit.

Road motor competition has only been felt during the last three or four years. In the case of goods it is so far very small, but for passengers, parcels, and luggage, it is becoming day by day more serious.

The loss which the railways have experienced as a whole is estimated at about 22 millions levas per annum.

The State has not so far organised any joint services with motor omnibuses in the different districts and has not made any arrangement with motor undertakings in order to co-ordinate the communications with the railways. At the present time Parliament is considering a proposed law dealing with the rights of the railways to impose an agreement of this kind.

In Bulgaria no railway line has been closed, although the position in several places is very unsatisfactory. A number of 600-mm. gauge lines have already been replaced by standard gauge lines for economic reasons, and in order to meet the requirements of the traffic.

Bulgaria is still a relatively new country. The railway system is still incompleted. As has already been said the construction of a number of lines is proposed, 1 300 km. (807.8 miles) of which will be secondary lines intended to connect to the main lines districts widely separated from the main centres, from the home markets, and from foreign countries.

These districts possess valuable minerals, forests, and farm lands, which are capable of great development as soon as they are connected by railways with the remainder of the country.

The secondary railways in Bulgaria, considered as feeder lines, have therefore a remarkable future parallel with the growth of the road motor, owing to the country offering great opportunities of development.

K. Italy. — The State Railway system has a development of 16 499 km. (10 252 miles), 15 773 km. (9 801 miles) of which are standard gauge, and 726 km. (451 miles), narrow gauge.

The group of narrow gauge railways operated by the State includes a number of lines in Tridentine Venetia, in Istria, which it is proposed to transfer shortly to private undertakings, and a system of secondary lines in Sicily, of the length of 462 km. (287 miles), 50 km. (31 miles) of which are rack railways. These lines have a gauge of 95 cm. (3 ft. 1 3/8 in.) which is that of the great majority of narrow gauge railways in the whole of Italy.

The Sicilian system is made up as a rule of lines having a very small traffic, built with the object of benefiting the land in this island, which will be able in the near future to develop its agricultural richness and mineral wealth and consequently produce a much heavier traffic. At the present moment the railway budget shows a deficit.

The track is laid with Vignoles rails weighing 27.3 kgr. per metre (55 lb. per yard), laid on wooden sleepers, on gravel ballast. Steam locomotives are used to work the trains.

The competition of road motor services is very appreciable and affects almost exclusively the tourists traffic which in this small island has developed very greatly.

The narrow gauge lines mentioned above were built in Sicily as means of communication of a local character and without any general plan of development. In order to meet the steadily growing needs of the island and owing to the very hilly nature of most of the districts concerned, it has been necessary to use the narrow gauge for the secondary lines, and the Government has considered the completion of this railway system by building new lines and branches so as to form a real system of economic railways, as self contained as possible, and intended to serve the consuming centres and the exportation ports.

This programme, when completed, will give very good results especially in the Western part of the island where the standard gauge railways were less developed, and where a well equipped system of lines of 95-cm. gauge is being built up.

The projects for the new secondary lines provide for maximum gradients of 25 mm. per metre (1 in 40), and curves of sufficiently large radius. The rack rail sections will be almost entirely suppressed and rails weighing 27.3 kgr. per metre (55 lb. per yard) will be used.

A wide and well organised system of public motor services will complete the communications between the centres of population, the chief towns and the sea.

A similar programme has been drawn

up by the headquarters of the Railway Administration in order to deal with the problem of the secondary railways in the hilly and mountainous districts of Calabra and the Basilicata wherein the lines of the great Companies have been developed along the seaboard with several transversal lines between the Tyrrhenian and Ionian seas. There were a considerable number of small cities which were situated at a great distance from the nearest station, and this situation which involved a journey lasting several hours by coach or by motor, made the progress and agricultural development of the region slower and more difficult. A project of a system of secondary lines of 95-cm. (3 ft. 1 3/8 in.) gauge connecting most of these towns together and to the sea ports was drawn up. In addition a third rail was laid on certain sections of the main system with little traffic in order to facilitate and increase the services between the secondary lines. This great programme which concurrently with the continual improvement of the land and the creation of new roads, is intended to restore the prosperity of the fine province of Calabra, has undergone during recent years important modifications of considerable utility imposed by the rapid development of public motor services. In fact it has been considered opportune to put off for the present the construction of the secondary railways of less importance while waiting until the road motor services (by motor omnibus and by motor lorry) has given the traffic a sufficient development and that in consequence it could be expected that the operation of the new railways would not show the same loss as it would today.

The railway system of Calabra, a part of which is already open to operation while the other is under construction, has been very usefully completed during recent years by a certain number of public automobile services, some of which are licensed for carrying goods as well as passengers, which makes the solution of the problem less costly whilst at the same time it does not in any way detract from its utility in developing the district.

The secondary railway system of Calabra, has on several sections gradients of 60 mm. per metre (1 in 17) and sometimes more. In order to avoid the use of rack railways, the concessionnaire Company has decided to use over these sections a particular type of locomotive especially designed for this purpose. The engine in question is a tender-locomotive having 8 coupled wheels and weighing in running order 43 t. (42.4 Engl. tons); it is fitted with the Riggenbach brake, the Westinghouse brake and a hand brake, with compressed air sanders acting on all the wheels in both directions of running.

This locomotive should have a speed of 15 km. (9.3 miles) an hour over gradienst of 60 mm. per m. (1 in 17). The tests which have been carried out have given satisfactory results, and the first three machines are now in regular service. Eight further locomotives of the same type fitted with Caprotti valve gear are being built by Messrs. Breda of Milan.

The problem of the utility and of the opportuneness of building and developing narrow gauge railways has received in the two cases that we have just considered a positive solution thanks to the particular condition of the zone served; but in other parts of Italy, this solution would hardly be advisable, and in a general way it is now considered desirable to reject it in all cases in which the construction of secondary standard gauge railways does not show too great practical difficulties.

In support of this idea we may quote the instructive example given by the railway system in the Modena province (about 100 km. [62 miles] of line), built several years ago in order to complete the existing trunk line operated by the State. This system of secondary lines serves a rich and populous agricultural region, consisting of plains and low hills, through which the construction of railways does not present any especial difficulties.

When preparing the scheme for the construction of these lines the gauge of 95 cm. (3 ft. 1 3/8 in) was adopted in order to reduce the cost, but the operating department of the system very soon showed that the solution selected had not been the best. Transporter trucks were then introduced into service, but the results, though slightly more favourable, were not satisfactory for the steadily increasing traffic, either to or from the secondary railways. Finally it had to be admitted that the only satisfactory solution was to completely alter the system by making it standard gauge and electrifying it : this proposal is at the present time being carried out.

In a short time it will be possible to meet under the best conditions the needs of the traffic, and the competition of motor lorries, and of public motor services.

This solution is the one that will be found essential for the vitality and growth of many of the systems, and of lines with consistently heavy traffic (the receipts of which exceed about 50 000 lires per kilometre [80 000 lires per mile]): standard gauge; layout in plan and profile the most favourable for operating; an economical and elastic organisation; a frequent service of light trains, and at high speeds.

The Reggio-Emilia Railway Company operates a system of about 80 km. (50 miles) the traffic conditions of which are very comparable to those of the Modena province mentioned above, but is of standard gauge.

The Reggio-Emilia system is in direct communication with the State Railways: as a result there has been a very considerable development of the goods traffic, and a marked growth in the general operating receipts, which have amounted to 80 000 lires per km. (129 000 lires per mile). The line is laid with rails of 27.3 kgr. per metre (55 lb. per yard), laid on wood sleepers or on Borini pattern reinforced concrete sleepers.

Steam locomotives are used to work the line. The competition of road motor vehicles both for passenger and goods traffic is already considerable, but taken as a whole the budget of the system shows a profit.

The question of electrification of the system has not yet been taken into hand.

The Vercelli Tramway Company (Piedmont) holds the concession in this province of a system of secondary railways of rather over 100 km. (62 miles) in length. The lines in question have the characteristics of old type tramways (1877 and 1880): light rails, steam traction with trains running at a very low commercial speed.

The line is made to standard gauge, but the presence of curves of too small radius, have not made it possible to establish direct services with the State Railways. As a result of these unfavourable conditions, the budget shows a deficit; consequently the Company has undertaken the application of a complete programme for the reconstruction of the system, substituting 27.3-kgr. (55 lb. per yard) rails for those of 18 kgr. (36.3 lb. per yard), re-alining and the use of electric traction.

Finally the operating will be organised under economical, modern and practical conditions. Although the competition of road motors is at the moment slight, the Company has already organised regular correspondance services with motor vehicles, and has obtained the concession of a line of public motor service over a length of 64 km.

(40 miles), which for a great part of the journey develops parallel to a line of tramways, and should facilitate and increase the traffic of the district with the market town. This public motor service is covered by large and luxurious vehicles, but the rates being higher than those of the tramway, the traffic remains divided into two groups: passengers of a distinct class, and passengers of low rate.

⁂

After having summed up in the preceding pages the information that we have received in connection with secondary railways we will now give the conclusions that emerge from this investigation. But before doing so we think it would be useful to reproduce here, some of the principal arrangements followed at the present time in Italy as regards the conditions the recently built railways and tramways have to fulfil in order to accept goods wagons running over the State Railways (Ministerial decree of the 27 March 1923):

1. On straight lines the normal gauge of the track should be 1.445 m. (4 ft. 8 7/8 in.) with a tolerance of 10 mm. (3/8 inch).

2. For curves of a radius equal to, or less than 650 m. (32 1/2 chains) the gauge should be in accordance with a special table, with an allowance of 3 to 5 mm. (1/8 to 3/16 inch).

3. The inclination of the rails on the vertical should be 1 in 20 towards the inside; this restriction does not apply to Phoenix rails.

4. The superelevation of the outer rail on curves should be calculated by the formula:

$$d = \frac{e\ V^2}{0.127\ R.}$$

This superelevation should be reduced by half in stations.

5. The minimum radius of curves is fixed at 150 m. (7 1/2 chains). It may be reduced to 120 m. (6 chains) on curves run through at reduced speed.

Straight sections laid in between two curves should have a length of at least 30 m. (98 ft. 5 1/8 in.).

6. The track should have sufficient strength to carry axle loads of 15 t. (14.8 English tons), even when the rails are worn to their extreme limit.

7. The weight of the rails per linear metre should not be less as a rule than 30 kgr. (60.5 lb. per yard). A lighter weight as small as 27 kgr. (54.4 lb. per yard) can be allowed.

8. The wooden sleepers shall have the following minimum dimensions: 2.30 m. × 220 mm. × 125 mm. (7 ft. 6 9/16 in. × 8 11/16 in. × 4 63/64 in.). Steel sleepers shall have a bearing surface of 2.30 m. × 220 mm. (7 ft. 6 9/16 in. × 8 11/16 in.); their weight shall not be less than 60 kgr. (133 lb.).

## CONCLUSIONS.

Most of the replies summed up above, to the questionnaire dealing with the construction of feeder railways in all the countries agree in their essential parts with the observations made in the foreword, and in the general conditions relating to such railways so that we can formulate the following conclusions:

*a*) There has been during recent years a marked slowing down in the construction of new secondary feeder railways. This fact is due to their too high cost of construction for economic operation and to the great difficulty they have in meeting the direct and appreciable competition of motor services which in most cases receive the preference of the public. If the countries through which the new Railways have to pass is hilly, and if the traffic is very small (representing for example less than 50 000 lires receipts per kilometre (80 000 lires per mile), the economical conditions are no longer in most cases favourable to the construction of the railway, and it is better to establish modern systems of public automobile services, both for passengers and goods;

*b*) The new secondary railways should be built in general to standard gauge and their layout should be such that under economical conditions of operation they allow the running of fast and frequent trains so as to meet the steadily growing requirements of the Public. The lines should be so designed as to allow of direct services with the rest of the system.

It is only in mountainous or very hilly countries when dealing with agricultural or forest undertakings, mines, or industries of little importance, and where the traffic is mostly local, that narrow gauge lines should be used. In this case in each country a standard gauge should be used, even if at the moment there is no connection between the secondary lines; it is also advisable to standardise the technical dimensions of the track and of the rolling stock in order to meet possible future developments, or for special needs in times of crisis. Care should also be taken as far as possible to avoid building rack railways.

In the case of the suburban lines of the great cities where the trains have to carry every day large numbers of workmen and employees living in the suburbs, the standardisation of the track and of the rolling stock in order to give possible direct services with other systems is of less importance;

*c*) For narrow gauge secondary railways serving districts where the traffic is great and where it is developing, it is very desirable to consider their reconstruction as standard gauge lines, whilst at the same time improving their layout and their methods of operation. Especially as regards many of the secondary railways who have to meet serious motor competition, a solution ensuring their vitality may be found in their electrification.

The consequences of these alterations : increase of the commercial speed of the trains, running of light trains at low cost and sufficiently numerous to meet all needs, reduction in the costs per train-kilometre, result in many cases in the improvement of the financial situation and make it possible to recover either all or part of the loss of traffic.

Under certain conditions the use of new systems of traction such as petrol or accumulator rail motors, have also given satisfactory results;

*d*) When the track is laid with too light rails [of a weight of less than say 23 or 25 kgr. per metre (48.4 to 50.4 lb. per yard)], the rolling stock also too light and of an out of date pattern, the trains slow and running at long intervals, the secondary railways are quite unable to meet the competition with road transport, and to meet the increasing requirements of the population concerned. Under these conditions they should be considered as a means of communication which ought to disappear;

*e*) The minimum weight of the rails used on secondary railways of recent construction should be 30 kgr. per linear metre (60.5 lb. per yard). In no case can a weight less than 25 kgr. (50.4 lb. per yard) be recommended;

*f*) In order to meet the competition of road motor services certain special measures can be used, and can be applied in most cases; these are the following :

*Passenger traffic:* increase in the speed and the frequency of the trains; running of light trains worked by rail motor coaches; issue of cheaper tickets in the suburbs of the great cities and during exhibitions, fairs, holidays, and holiday season, etc. Direct operation or control of public road motor services running in parallel (that is to say in competition) or as feeders to the railway.

*Goods traffic :* better organisation of the trains in order to reduce the time taken to deliver; simplification of the various operations in the stations; introduction of special reduced rates for the carriage of a certain tonnage of goods; acceptance of group consignments at special prices; organisation of collecting and delivering services in conjunction with cartage firms directly controlled by the railway;

*g*) In the interests of a cheap and elastic operation of the secondary railways, the train dispatching system should be adopted;

*h*) When carrying goods in transit over railways of different gauges it is desirable to introduce and extent the *container* system, the advantages of which both for the railways and for the motor lorries are incontestable, and are generally admitted. As regards the use of transporter trucks, for fully loaded wagons, between railways of different gauges, it is only suitable for small quantities of goods and for short distances and does not always give appreciable savings;

*i*) Collaboration between the secondary railways and the public motor services is to be recommended in most cases and should be favoured by the legislation of cach country. This collaboration is now essential for the vitality of most of the light railways by preventing the ruinous tariff wars and the useless dispersion of energy, activity and wealth from which the Public itself often derives no profit.

[ 621. 134 ]

# REPORT No. 4

### (British Empire, China and Japan)

## ON THE QUESTION OF IMPROVEMENTS IN THE STEAM LOCOMOTIVE (SUBJECT VI FOR DISCUSSION AT THE ELEVENTH SESSION OF THE INTERNATIONAL RAILWAY CONGRESS ASSOCIATION) (1),

By H. N GRESLEY,

CHIEF MECHANICAL ENGINEER, LONDON AND NORTH EASTERN RAILWAY.

Figs. 1 to 23, pp. 2692 to 2738.

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CHAPTER II. — Superheating.

CHAPTER III.— Feedwater heating.

CHAPTER IV. — Air preheating.

CHAPTER V. — Valves and valve gear.

CHAPTER VI. — Arrangement of front end.

CHAPTER VII. — Miscellaneous.

*a*) Compounding.
*b*) Combustion in fireboxes.
*c*) Circulation in boilers.
*d*) Regulators.
*e*) Steam dryers or separators.
*f*) Soot blowers.
*g*) Boosters.
*h*) Use of special alloy steel.
*i*) Use of special light alloys.

The following is a list of the Administrations from whom replies have been received :

**China and Japan.**

South Manchuria Railway.
Japanese Government Railways.
Chosen Government Railways.

**Great Britain.**

Great Western Railway.
London Midland & Scottish Railway.
London & North Eastern Railway.
Southern Railway.
Cheshire Lines Committee.
Great Northern Railway of Ireland.
Kent, Somerset, Shropshire & Welsh Light Railways Group.
London Midland & Scottish Railway, Northern Counties Committee.
Great Central & Midland Joint Committee.
Midland & Great Northern Railways Joint Committee.

**Africa.**

Kenya and Uganda Railway.
Mashonaland Railway.
South African Railways and Harbours.
Sudan Government Railways and Steamers.

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(1) This question runs as follows : « Improvements in the steam locomotive. Increased pressures and higher superheats. Improvements in the design of superheaters and parts connected with superheating. Feed water heating and air preheating. Improvements of valve gears. »

**Australasia.**

New South Wales Government Railways.
New Zealand Government Railways.

**Canada.**

Canadian National Railways.

**India.**

Burma Railways.
Bengal and North Western Railway.
Bombay, Baroda and Central India Railway.
Eastern Bengal Railway.
East Indian Railway.
Great Indian Peninsula Railway.
Madras and Southern Mahratta Railway.
North Western Railway.
Rohilkund and Kumaon Railway.
South Indian Railway.
Ceylon Government Railway.

**Malaysia.**

Federated Malay States Railways.

**Mesopotamia.**

Iraq State Railways.

# CHAPTER I.

## Increased boiler pressure.

1. — **Recognised standard boiler pressure on passenger and goods locomotives built since 1922.**

Table I shows Railway Administations using boiler pressures in excess of 200 lb. per square inch.

2. — **Particulars of any boiler having increased pressure up to 284 lb. per square inch.**

The engines of the Great Western, the Canadian National, the Southern and the London Midland & Scottish Railways in question were new designs and consequently no comparison with the Companies' previous locomotives could be made.

Railways reporting the use of increased pressure on existing engines are the Great Northern (Ireland) which has experimented with 200 lb. per square inch in place of 170 on eight 4-4-0 express locomotives, and the London & North Eastern (England) which, as an experiment for comparative purposes, has fitted fifteen 4-6-2 express locomotives with boilers having the working pressure increased from 180 to 220 lb. per square inch in order to gain knowledge of the relative maintenance and operating costs of similar engines working at these respective pressures.

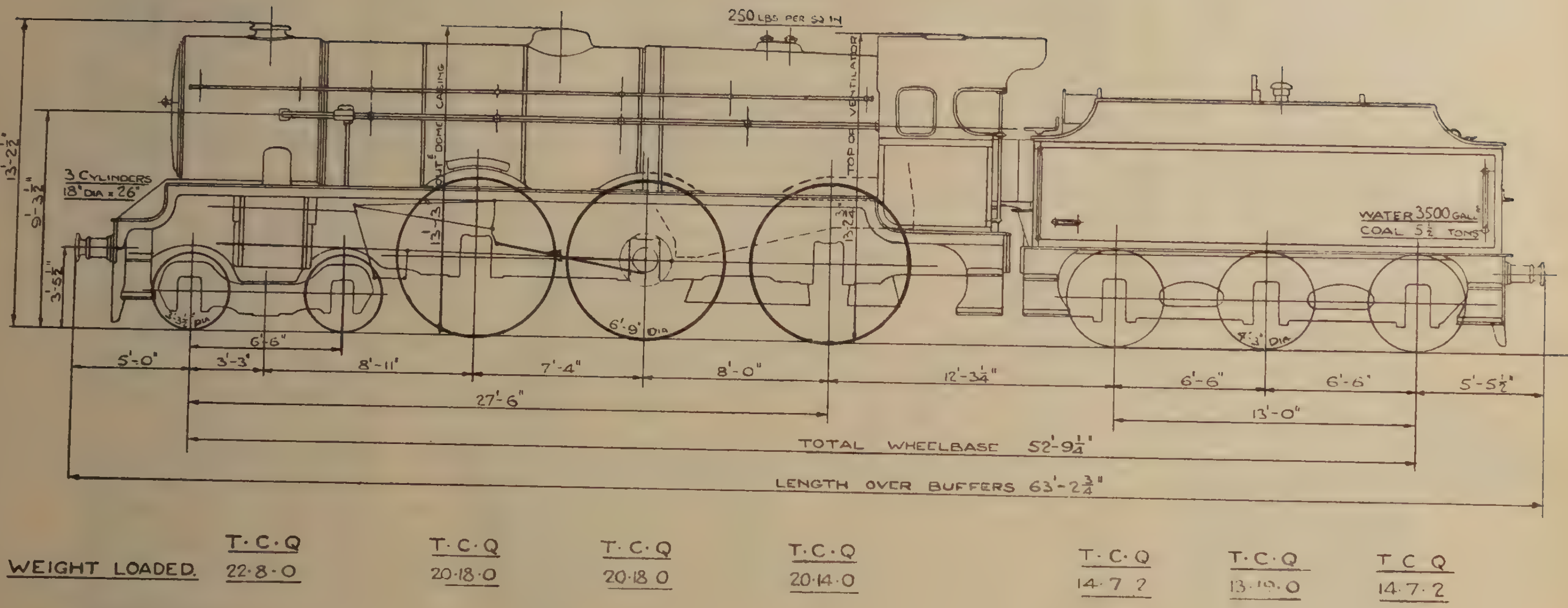
Particulars of the engines shown in figures 1, 2, 2*a* and 3 are given in table I.

3. — **Results of tests of such boilers.**

The Great Northern of Ireland report no noticeable difference in fuel and water consumption as a result of increasing the pressure on their main line engines from 170 to 200 lb. The London & North Eastern Railway have carried out careful dynamometer tests between *Pacific* engines having 180 and 220 lb. boiler pressure, the diameter of the cylinders of the engine having 220 lb. boiler pressure having to be reduced so as to produce the

General arrangement of engines using boiler pressures in excess of 200 lb. per square inch.

| — | *London Midland & Scottish Ry. Royal Scot* class, 4-6-0. | *Great Western Railway,* 4-6-0. | *London & North Eastern, Pacific* type 4-6-2. | *Southern,* 4-6-0. | *Great Northern of Ireland,* 4-4-0. | *South African Railways.* | *New Zealand Government Railways.* | *Canadian National Railways.* |
|---|---|---|---|---|---|---|---|---|
| Number of wheels driving. | 4 | 4 | 2 | 4 | ... | ... | ... | 8 |
| Number of wheels coupled. | 6 | 6 | 6 | 6 | 4 | ... | ... | 8 |
| Diameter of coupled wheels. | 6'-9" | 6'-7" | 6'-7" | 6'-8" | 6'-6" | ... | ... | ... |
| Area of grate, in square feet. | 31.2 | 34.3 | 41.25 | 33.0 | ... | ... | ... | 66.8 |
| Heating surface of firebox, sq. feet. | 189 | ... | 215 | 194 | ... | ... | ... | 384 |
| Heating surface of tubes, sq. feet. | 1892 | ... | 2 521.6 | 1 795 | ... | ... | ... | 3 472 |
| Superheating surface, sq. feet. | 399 | ... | 706 | 376 | ... | ... | ... | 968 |
| Boiler pressure, lb. per square inch. | 250 lb. | 250 lb. | 220 lb. | 220 lb. | 200 lb. | 215 lb. | 230 lb. | 250 lb.<br>210 lb. |
| Number of cylinders . | 2 outside, 1 inside. | 2 outside, 2 inside. | 3 outside, 1 inside. | 2 outside, 2 inside. | ... | ... | ... | 2 outside. |
| Diameter of cylinders . | 18" | 16 1/4" | 19" | 16 ½" | 19" | ... | ... | 26" |
| Stroke of piston . . . | 26" | 28" | 26" | 26" | 26" | ... | ... | 28" |
| Weight of engine in running order. | 84 T. 18 C. | 89 T. | 96 T. 5 C. | 83 T. 10 C. | 52 T. 10 C. | ... | ... | 149 T. |
| Weight of engine on coupled wheels. | 62 T. 10 C. | 67 T. 10 C. | 66 T. 3 C. | 61 T. 19 C. | ... | ... | ... | ... |
| Total weight of engine and tender. | ... | ... | 159 T. 6 C. | 104 T. 4 C. | ... | ... | ... | ... |
| Tractive effort . . . | 33 150 lb. at 85 % B. P. | 40 300 lb. | 32 909 lb. at 85 % B. P. | 33 500 lb. at 85 % B. P. | 20 198 lb. | ... | ... | 44 000 lb. |
| Class of work . . . . | Express passenger. | Express passenger. | Express passenger. | Express passenger. | Express passenger. | ... | ... | Express passenger and freight. |



*Heating surface:*

| | | |
|---|---|---|
| Tubes | 1 892 | sq. feet. |
| Firebox | 189 | sq. feet. |
| Total | 2 081 | sq. feet. |
| Superheater | 399 | sq. feet. |
| Grate area | 31.2 | sq. feet. |
| *Tractive effort* at 85 % B. P. | 33 150 | lb. |

| | | Loaded<br>T. C. Q | Light<br>T. C. Q. |
|---|---|---|---|
| Total weight | Engine | 84.18.0 | 77.18.2 |
| | Tender | 42.14.0 | 21.11.2 |
| | Engine and tender | 127.12.0 | 99 10.0 |

Fig. 1. — Diagram of London Midland and Scottish 4-6-0 express passenger locomotive.

same tractive effort as the engine having 180 lb. pressure. The engines were tested on express passenger trains running between Doncaster and King's Cross with the Company's dynamometer car attached, one double trip being made daily. The tests extended over a fortnight.

Two sets of men were employed and they were changed over in the middle of each week to eliminate any difference that might arise due to the different methods of working. Throughout the tests the engines were worked with full regulator as much as possible, variation in power required being obtained by varying the cut off in the cylinders. A continuous record was taken in the dynamometer car of drawbar pull, work done by the locomotive, and the speed: the gradients were recorded and the position of mile posts and the passing times.

A supply of Yorkshire hard coal was put on one side for the two engines during the trials. The coal was weighed on and off daily, a supply for lighting up and making up the fire being kept separate in bags, the amount of fire in the box at the commencement and end of each trip being kept as nearly alike as possible. The steam used in heating the trains was included and was found by observations taken by a meter of the Venturi type, to be responsible for between 4 and 5 % of the total water used.

*a*) The results of the tests on fuel and water consumption are as follows:

**Dynamometer car tests. — February 1928.**

| — | Engine No. 4473. Boiler pressure : 180 lb. per sq. inch. | Engine No. 2544. Boiler pressure : 220 lb. per sq. inch. |
|---|---|---|
| Weight of train with dynamometer car, tons . . . | 419.79 | 428.2 |
| Total weight of engine, car and train, tons . . . . | 559.78 | 569.2 |
| Ton-miles (excluding engine) . . . . . . . . . . | 65 937.5 | 66 654.0 |
| Ton-miles (including engine) . . . . . . . . . . | 87 766.6 | 89 114.0 |
| Average speed, miles per hour . . . . . . . . . | 52.8 | 54.7 |
| Average drawbar pull, tons . . . . . . . . . . | 2.1 | 1.9 |
| Total work done by engine in horse power-hours . . | 1 970.0 | 1 770.0 |
| Average drawbar horse power . . . . . . . . . | 668.3 | 618.5 |
| Maximum drawbar horse power . . . . . . . . | 1 041.8 | 1 060.0 |
| Horse power-hours per train mile . . . . . . . | 12.6 | 11.3 |
| *Water.* | | |
| Pounds per ton-mile (including engine) . . . . . | 0.58 | 0.50 |
| Pounds per drawbar horse power-hour . . . . . | 26.3 | 26.7 |
| *Coal.* | | |
| Pounds per mile . . . . . . . . . . . . . . . | 40.6 | 37.0 |
| Pounds per ton-mile (excluding engine) . . . . . | 0.0959 | 0.086 |
| Pounds per ton-mile (including engine) . . . . . | 0.0721 | 0.064 |
| Pounds per drawbar horse power-hour . . . . . | 3.20 | 3.26 |
| Average per square foot of grate area per hour, in pounds . . . . . . . . . . . . . . . . . . . | 51.9 | 49.0 |
| Evaporation, in pounds of water per pound of coal . | 8.2 | 8.17 |

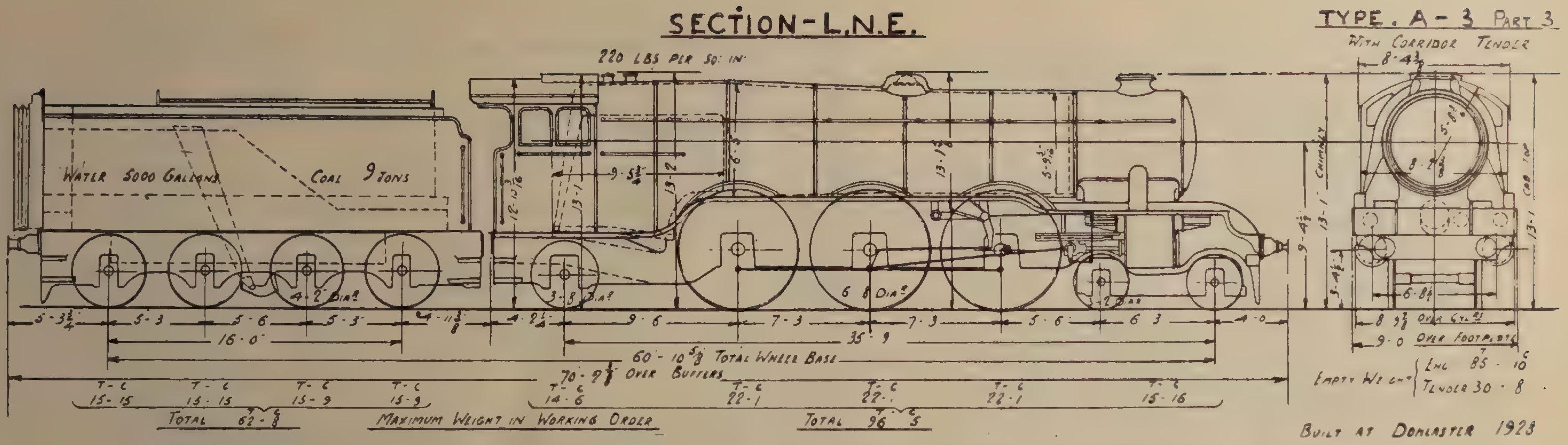


Fig. 2. — Diagram of London & North Eastern Railway 4-6-2 express passenger locomotive with corridor tender, 220 lb. pressure.

## *Leading dimensions and ratios.*

*Grate:*

| | |
|---|---|
| Length on slope | 5′—10 15/16″ |
| Width | 6′—11 3/4″ |
| Grate area | 41.25 sq. feet. |

*Firebox:*

| | | |
|---|---|---|
| Height of crown above foundation ring | front | 6′— 8 13/16″ |
| | back | 6′— 6 5/16″ |
| Interior length at top | | 7′—11 3/4″ |
| Interior width at boiler centre | | 5′— 4 1/2″ |
| Thickness of copper plates | sides and back | 9/16″ |
| | tube plate | 9/16″ and 1 1/4″ |

*Boiler:*

| | |
|---|---|
| Outside length firebox overall. | 9′— 5 3/4″ |
| Outside length firebox at bottom. | 6′— 8″ |
| Outside width firebox at bottom. | 7′— 9″ |
| Diameter of barrel, max. | 6′— 5″ |

*Boiler:*

| | |
|---|---|
| Length of barrel | 19′— 0″ |
| Thickness of barrel plates | 23/32″ and 25/32″ |
| Thickness of wrapper plates. | 9/16″ |
| Outside diameter of smokebox. | 6′— 0″ |
| Length | 5′—11 3/4″ |

*Tubes — small:*

| | |
|---|---|
| Material | Steel. |
| Number | 125 |
| Diameter outside | 2 1/4″ |
| Thickness | 10 I.W.G. |

*Tubes — superheater flues:*

| | |
|---|---|
| Number | 43 |
| Diameter outside | 5 1/4″ |
| Thickness | 5/32″ |
| Length between tube plates | 18′—11 3/4″ |

*Heating surface:*

| | |
|---|---|
| Firebox | 215 sq. feet. |
| Tubes 2 1/4″ | 1 398.8 » |
| Flues | 1 122.8 » |
| Total evaporative heating surface | 2 736.6 » |

*Superheater:*

| | |
|---|---|
| Number of elements | 43 |
| Diameter inside | 1 7/32″ |
| Heating surface | 706 sq. feet. |
| Total heating surface | 3 442.6 » |
| Two Ross pop safety valves | 3 1/2″ diam. |
| Working pressure | 220 lb./sq. in. |
| Boiler horse power | 1749 |

*Axles:*

| | Diam. | Length |
|---|---|---|
| Journals, bogie | 6 1/2″ | × 9″ |
| Coupled wheels | 9 1/2″ | × 11″ |
| Trailing | 6″ | × 11″ |
| Crank pins outside | 5 1/2″ | × 6″ |
| Crank pins inside | 8 1/4″ | × 6″ |
| Coupling pins leading. | 4″ | × 4 1/2″ |
| Coupling pins driving. | 6″ | × 4 1/4″ |
| Coupling pins trailing. | 4″ | × 4 1/2″ |

*Springs:*

Bogie: helical 10 1/2″ long free. 1 5/16″ outs. diam. Timmis section.
Coupled wheels: laminated 3′—6″ crs. 11 plates 5″ wide × 5/8″ thick.
Trailing: laminated 4′—6″ crs. 11 plates 5″ wide × 5/8″ thick.

*Cylinders:*

| | |
|---|---|
| Number | 3 |
| 19″ diam. × 26″ stroke | |
| Cylinder horse-power | 2 142. |

*Motion:*

| | |
|---|---|
| Type outside | Walschaerts. |
| Type inside | Gresley. |
| Type of valve | piston. |
| Diam. of valve | 8″ |
| Max. travel of valves | 5 3/4″ |
| Steam lap: | 1 5/8″ outside cylinders. |
| — | 1 11/16″ inside cylinder. |
| Exhaust lap | Nil. |
| Cut off in full gear. | 65 % |

| | |
|---|---|
| Tractive effort at 85 % boiler pressure. | 32 909 lb. |
| Total adhesive weight | 148 176 lb. |
| Adhesive weight ÷ tractive effort. | 4.32 |

Vacuum brake.

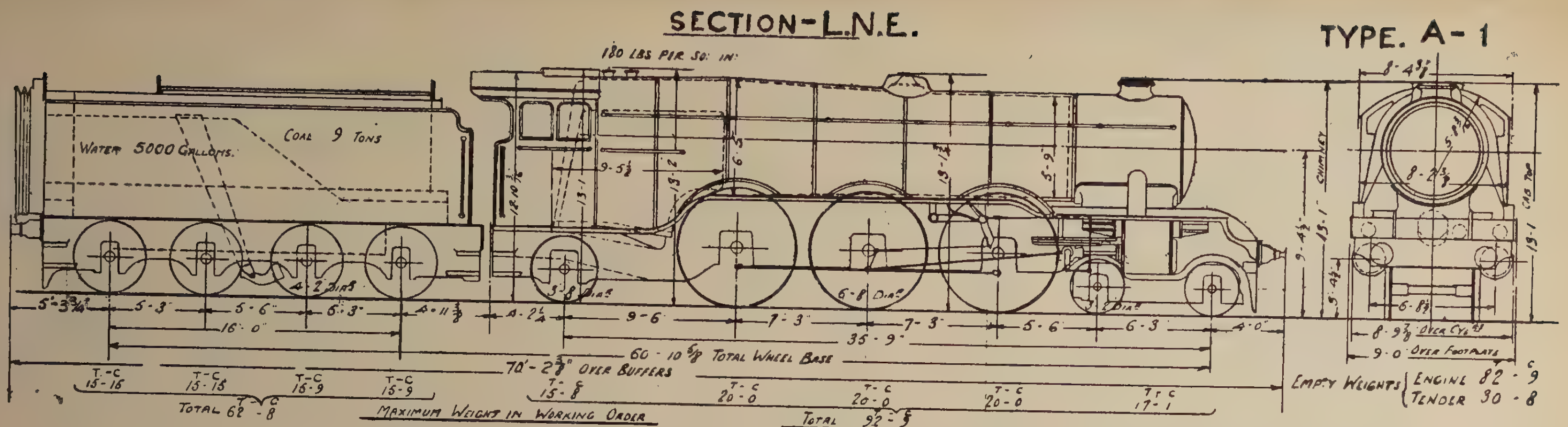


Fig. 2*a*. — Diagram of London & North Eastern Railway 4-6-2 express passenger locomotive with corridor tender, 180 lb. pressure.

*Leading dimensions and ratios.*

*Grate:*

| | |
|---|---|
| Length on slope | 5'—10 15/16" |
| Width | 6'—11 3/4" |
| Grate area | 41.25 sq. feet. |

*Firebox:*

| | | |
|---|---|---|
| Height of crown above foundation ring | front | 6'—8 13/16" |
| | back | 6'—0 5/16" |
| Interior length at top | | 7'—11 3/4" |
| Interior width at boiler centre | | 5'—4 1/2" |
| Thickness of copper plates | sides and back | 9/16" |
| | tube plates | 9/16 and 1" |

*Boiler:*

| | |
|---|---|
| Outside length firebox overall. | 9'—5 1/2" |
| Outside length firebox at bottom. | 6'—8" |
| Outside width firebox at bottom. | 7'—9" |
| Diameter of barrel, max. | 6'—5" |
| Length of barrel | 19'—0" |
| Thickness of barrel plates. | 5/8" and 11/16" |

*Boiler:*

| | |
|---|---|
| Thickness of wrapper plates. | 9/16" |
| Outside diam. of smokebox. | 6'—0" |
| Length of smokebox | 5'—11 3/4" |

*Tubes* — small: *Robinson superheater.*

| | |
|---|---|
| Material | Steel |
| Number | 168 |
| Diameter outside | 2 1/4" |
| Thickness | 10 I.W.G. |

*Tubes* — Superheater flues:

| | |
|---|---|
| Number | 32 |
| Diameter outside | 5 1/4" |
| Thickness | 5/32" |
| Length between tube plates | 19'—0" |

*Heating surface:*

| | |
|---|---|
| Firebox | 215 sq. feet |
| Tubes 2 1/4" | 1 880 sq. feet |
| Flues | 835 sq. feet |
| Total evaporative heating surface | 2 930 sq. feet |

*Superheater:*

| | |
|---|---|
| Number of elements | 32 |
| Diameter inside | 1 1/4" |
| Heating surface | 525 sq. feet |
| Total heating surface | 3 455 sq. feet |
| Two Ross pop safety valves. | 4" diam. |
| Working pressure | 180 lb./sq. in. |
| Boiler horse power. | 1 815 |

*Axles:*

| | Diam. Length |
|---|---|
| Journals bogie | 6 1/2" × 9" |
| Coupled wheels | 9 1/2" × 11" |
| Trailing wheels | 6" × 11" |
| Crank pins outside. | 5 1/2" × 6" |
| Crank pins inside | 8 1/4" × 6" |
| Coupling pins leading | 4" × 4 1/2" |
| Coupling pins driving | 6" × 4 1/4" |
| Coupling pins trailing | 4" × 4 1/2" |

*Springs:*

Bogie: helical 10 1/2" long free. 5 1/16" outs. diam. Timmis section.

*Spings* (continued).

Coupled wheels: laminated 3'—6" crs. 11 plates 5" wide × 5/8" thick.

*Cylinders:*

| | |
|---|---|
| Number | 3 |
| 20" diameter × 26" stroke | |
| Cylinder horse power | 1 946 |

*Motion:*

| | |
|---|---|
| Type outside | Walschaerts |
| Type inside | Gresley |
| Type of valve | piston |
| Diam. of valve | 8" |
| Max. travel of valves | 5 3/4" |
| Steam lap 1 5/8" outside, 1 11/16" inside. | |
| Exhaust lap | Nil. |
| Cut off in full gear | 65 % |
| Tractive effort at 85 % boiler pressure | 29 835 lb. |
| Total adhesive weight | 134 400 lb. |
| Adhesive weight ÷ Boiler horse power | 4.5 |

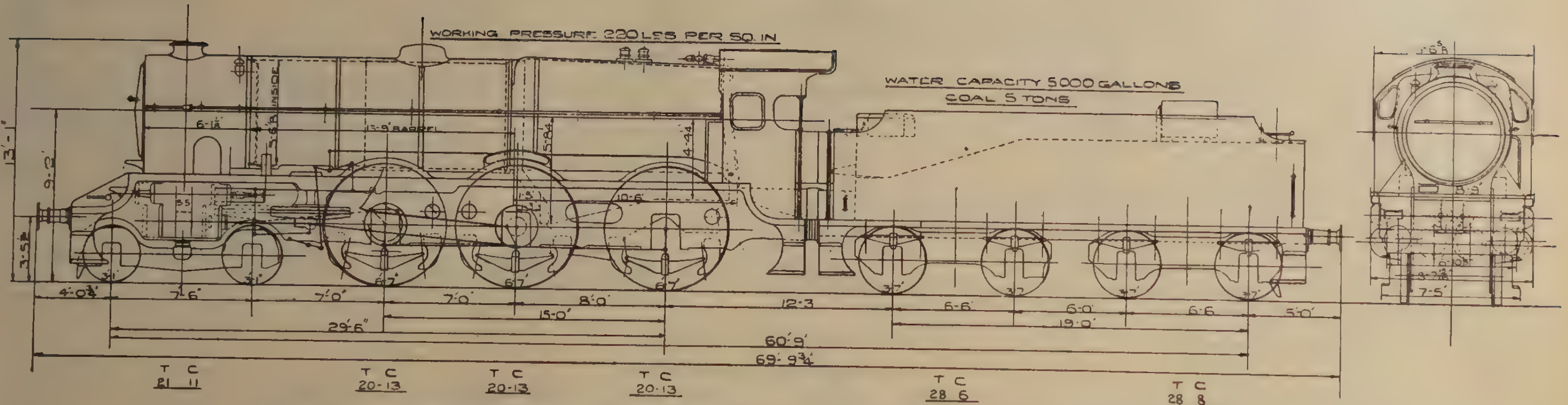


Fig. 3. — Diagram of Southern Railway 4-6-0 express passenger locomotive, working pressure 220 lb.

*Heating surface:*

| | |
|---|---|
| Small flue tubes (2″ diam.) . . . . . . | 1 282 sq. feet |
| Large flue tubes (5 1/4″ diam.) . . . . . | 513 — |
| Firebox . . . . . . . . . . . . . . | 194 — |
| Total . . . . . . . . . . . . . . | 1 989 — |
| Superheater — (1 3/32″ diam. elements). . | 376 — |
| Total heating surface . . | 2 365 sq. feet |

| | | |
|---|---|---|
| *Grate area* . . . . . . . . . . . . . | 33.50 sq. feet | |

*Cylinders:*

16 1/2″ diam. × 26″ stroke.

| | | |
|---|---|---|
| Tractive force 85 % boiler pressure . . . . . | 33 500 lb. | |
| Total weight on coupled wheels . . . . | 61 tons | 19 cwt. |
| — of engine in working order | 83 | 10 — |
| — of engine empty . . . . | 75 | 16 — |

*Cylinders:*

| | | |
|---|---|---|
| Total weight of tender in working order | 56 tons | 14 cwt. |
| — of tender empty . . . . | 29 | 12 — |
| — of engine and tender in working order . . . . . | 140 — | 4 — |
| — of engine and tender empty | 105 | 8 — |

$$\frac{\text{Tractive force}}{\text{Adhesive weight}} = \frac{33\,500}{61.95} = 540 \text{ lb. per ton.}$$

*b) The superheat obtained.* — Replies received do not indicate any appreciable increase in the superheat obtained as a result of increasing the boiler pressure. On the London & North Eastern trials, an increased superheat of 7 % is reported, but the conditions were not comparable as the higher pressure boiler was fitted with a superheater having 43 elements whereas the lower pressure boiler had only 32 elements.

### 4. — The effect of increased pressure on maintenance, etc.

No complete replies were received to this question.

*a*) Replies received indicate no noticeable difference except the London & North Eastern, who report that there is a marked increase in the amount of repairs required to fireboxes of boilers having higher pressure. Such repairs largely appear to neutralise the economy obtained in fuel consumption.

b) *Repairs to cylinders, valves, pistons and packing.*

*b*) No railways report any effect produced by higher boiler pressure on repairs to cylinders.

c) *Time engines are out of traffic.*

No replies received on this question.

d) *Cost of repairs.*

See reply to *a*).

e) *Cost of lubrication.*

Such railways as reply, have noticed no increase in the cost of lubrication as a result of higher pressure boilers.

f) *Periodical examination of :*

I. Boiler.
II. Valves and pistons.

No alteration appears to be necessary in the periodical examination of boilers or valves and pistons.

g) *Details of any failures of parts, etc. occurring in service due to the increase in pressure.*

No failures due to increase in boiler pressure have been reported.

### 5. — General remarks as to raising boiler pressure above recognised standard.

The result of increasing the boiler pressure appears to have produced economy in fuel and water consumption. At the same time it is reported that there is an increase in the cost of maintenance of fireboxes which may go so far as to neutralise the economies effected in fuel consumption. It is desirable, therefore, that further experience as a result of increasing the boiler pressure should be obtained.

Higher pressures have resulted in more powerful locomotives being built within the loading gauge limits and this is of special value when it is required to provide more powerful locomotives than those already in service which have been built to the extreme limits allowed by the loading gauge.

# CHAPTER II.

## Superheating.

1. — *Give particulars of any experimental superheaters used, giving temperatures exceeding 700° F.*

a) *Results obtained, temperatures and amount of coal saved.*

b) *What modifications, if any, had to be made to :*

1. *Valves, pistons and packing.*
2. *Lubricators and lubricants (specification of oils to be attached).*
3. *Exhaust or blast pipe and chimney and smoke box.*
4. *Header.*
5. *Regulator.*

c) *Effect on maintenance :*

1. *Repairs required in service.*
2. *Cost of repairs to superheater.*
3. *Details of any part which has given trouble and steps taken to remedy it.*

No railway reports experiments in connection with the use of higher superheat, i. e. above 700° F.

2. — a) *What is the maximum temperature considered practicable in locomotive work ?*

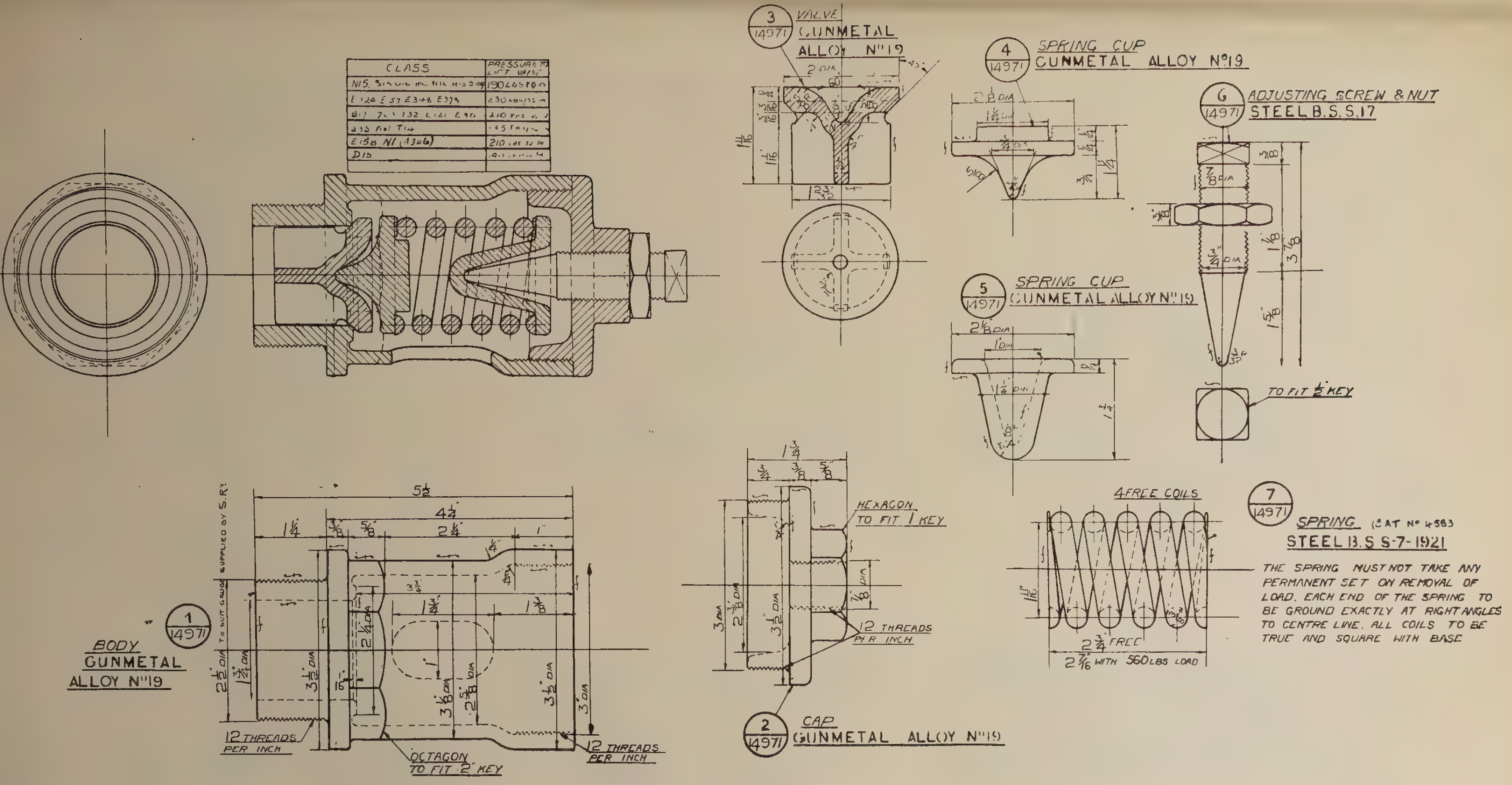
750° F. appears to be the highest temperature that can be generally regarded as satisfactory in locomotive work although some companies have recorded temperatures as high as 800° F. With temperatures not exceeding 750° F. there is no difficulty with packings and lubrication, and consequently this figure should not be exceeded with standard designs. In 1926 the London Midland & Scottish fitted up 200 engines for oil burning. A burner of the Mexican trough type was used, and the superheat obtained often reached nearly 800° F. There was difficulty with piston rod packing due to the high steam temperature. The difficulty was overcome by changing the white metal, 70 % lead, 30 % antimony, to a special bronze alloy packing, *viz.*, 96 % copper, 2 % antimony, 2 aluminium.

b) *What type and make of pyrometer is fitted and is it found necessary to fit all superheated engines with pyrometers?*

The general practice is to fit pyrometers only when required for experimental purposes. The reports received cover all the leading makes of pyrometers, of mercury types, tension types and electrical types, no new design having made its appearance. The conclusion to be drawn is that pyrometers serve no really useful purpose in ordinary working and consequently need not be fitted as a general rule.

c) *What types of cylinder relief valves, snifting valves or bye-passes are used ?*

Cylinder relief valves are generally used. Figure 4 [Southern Railway (G. B.)] and figure 5 [Indian State Rail-



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MARK & QUANTITIES REQUIRED

| ORDER OR CLASS | 1 / 14971 | 2 / 14971 | 3 / 14971 | 4 / 14971 | 5 / 14971 | 6 / 14971 | 7 / 14971 | |
|---|---|---|---|---|---|---|---|---|
| N15 SPARE. E158. | 4 | 4 | 4 | 4 | 4 | 4 | 4 | |
| E.124 E157. E348. | 8 | 8 | 8 | 8 | 8 | 8 | 8 | |
| B 189 N1 (A 346) E378 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | |

Fig. 4. — Cylinder release valve, — Southern Railway.

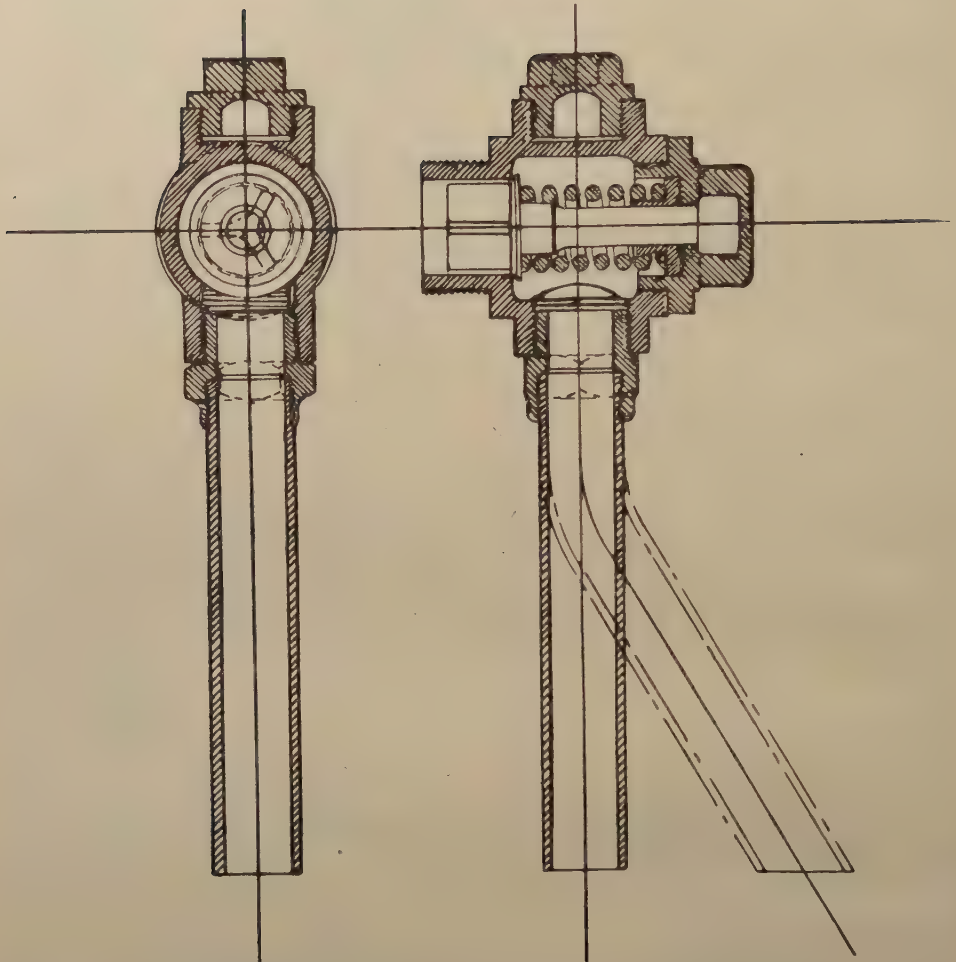


Fig. 5. — Cylinder cock and cylinder relief valve as used on Indian State Railways.

ways] show arrangements of such valves. Cylinder relief valves are generally set to open at 10 lb. to 20 lb. above the boiler pressure.

Snifting valves are in general use on locomotives not fitted with bye-pass valves.

Bye-pass valves are used by a number of companies and their use is diminishing except in India where Hendries valve is being extensively used (see fig. 6).

The Southern Railway report that they are discontinuing the use of bye-pass valves and using air-relief valves on the header casting (see fig. 7).

The position as to snifting valves and

bye-pass valves cannot be said to be final. There is need for further investigation now that improved valve gears are available, and especially into the use of snifting valves to see what is the thermal loss due to the cooling down of the elements by the admission of cold air, and to make clear the effect of hot dry air on the oil film on the steam chest and cylinder walls.

# CHAPTER III.

## Feed water heating.

### A. — Heaters in which water is heated by combustion gases.

No railways report that they are fitting feed water heaters of this type. Although in the past some experiments have been made, it is not considered that there is as great a prospect of securing the desired economies if feed water derives its heat from combustion gases as there is, if it is heated by exhaust steam.

### B. — Exhaust steam injectors.

Ten railways report that they are using exhaust steam injectors of the Davies & Metcalfe type.

### C. — Exhaust steam feed water heaters. — Feed water passing through tubes heated on the outside by exhaust steam.

Eleven railways report that they are using feed water heaters of this type. The makers of the heaters most used are the Weir, Elesco and Coffin.

The replies indicate that the Elesco heaters are used in greater numbers than other makes. All these heaters are operated by steam reciprocating pumps except the Coffin, which has a rotary pump.

### D. — Exhaust steam feed water heaters in which exhaust steam comes in direct contact with the feed water.

Thirteen railways report that they are using this type of heater.

The makers of heaters of this type reported are :

Worthington Simpson (see fig. 8).
Weir (see fig. 9).
Dabeg (see fig. 10).
A. C. F. I. (see fig. 10*a*).
Yamanato.

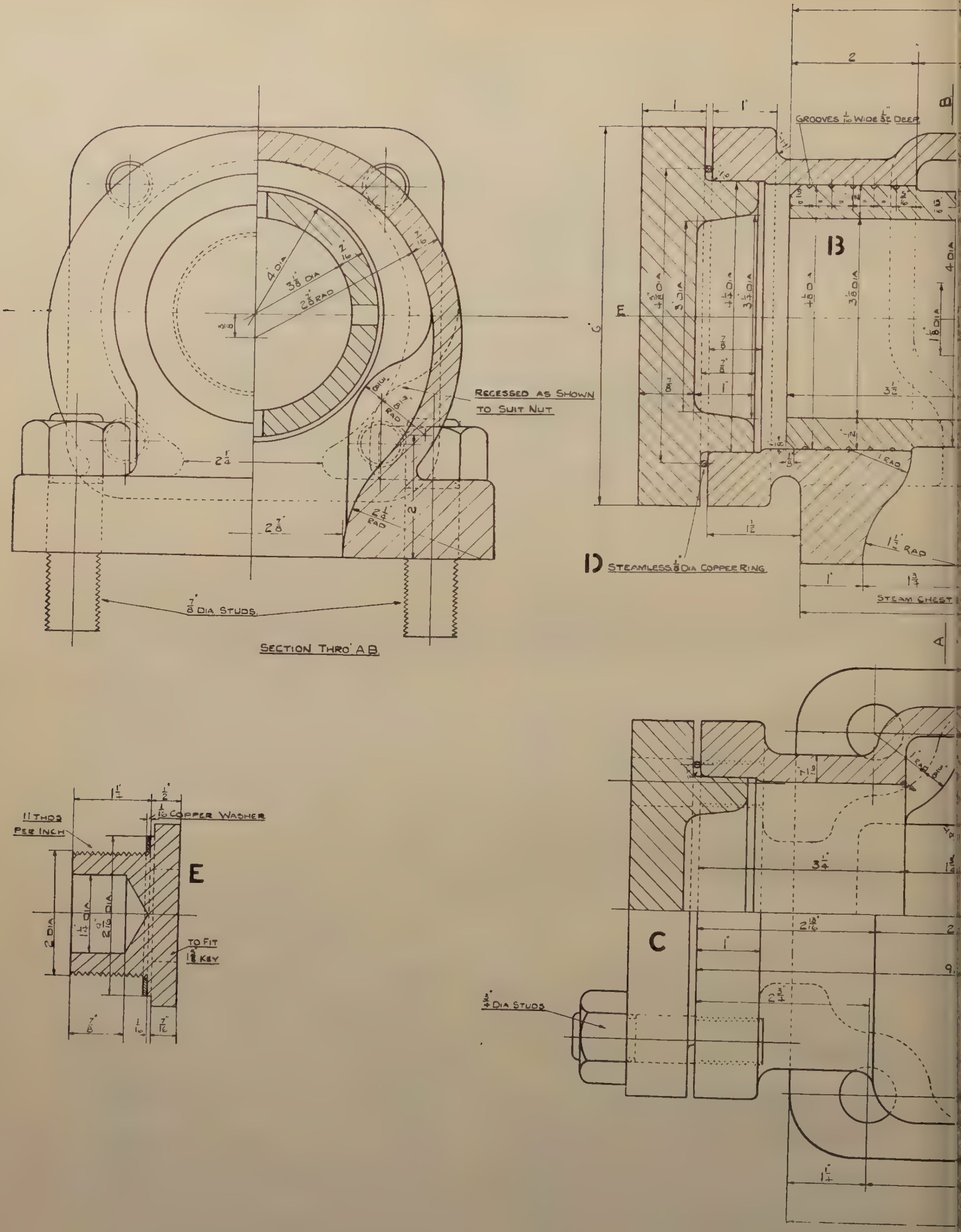
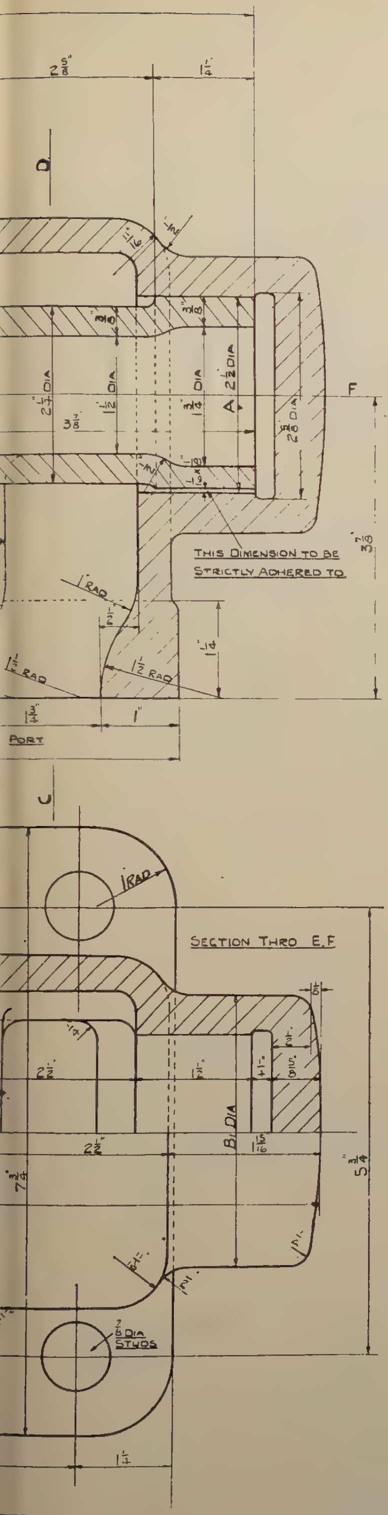
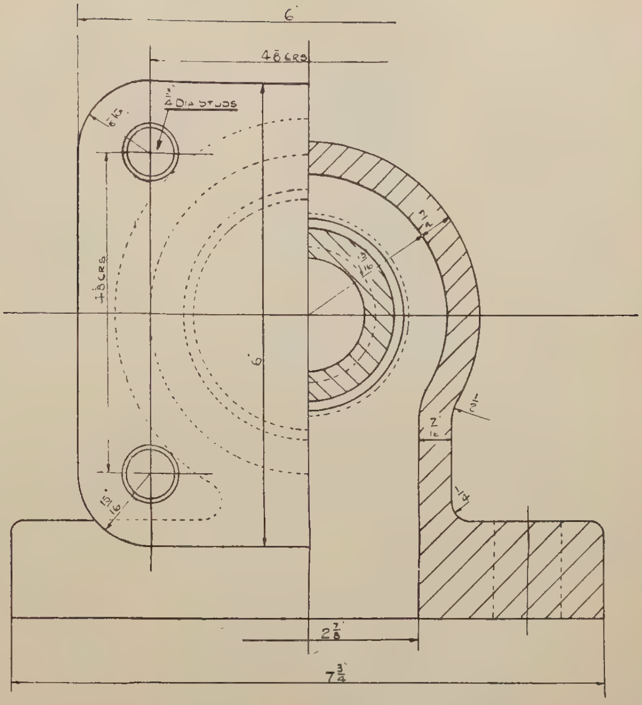


Fig. 6. — Bye-pass valve for North Western Railwa



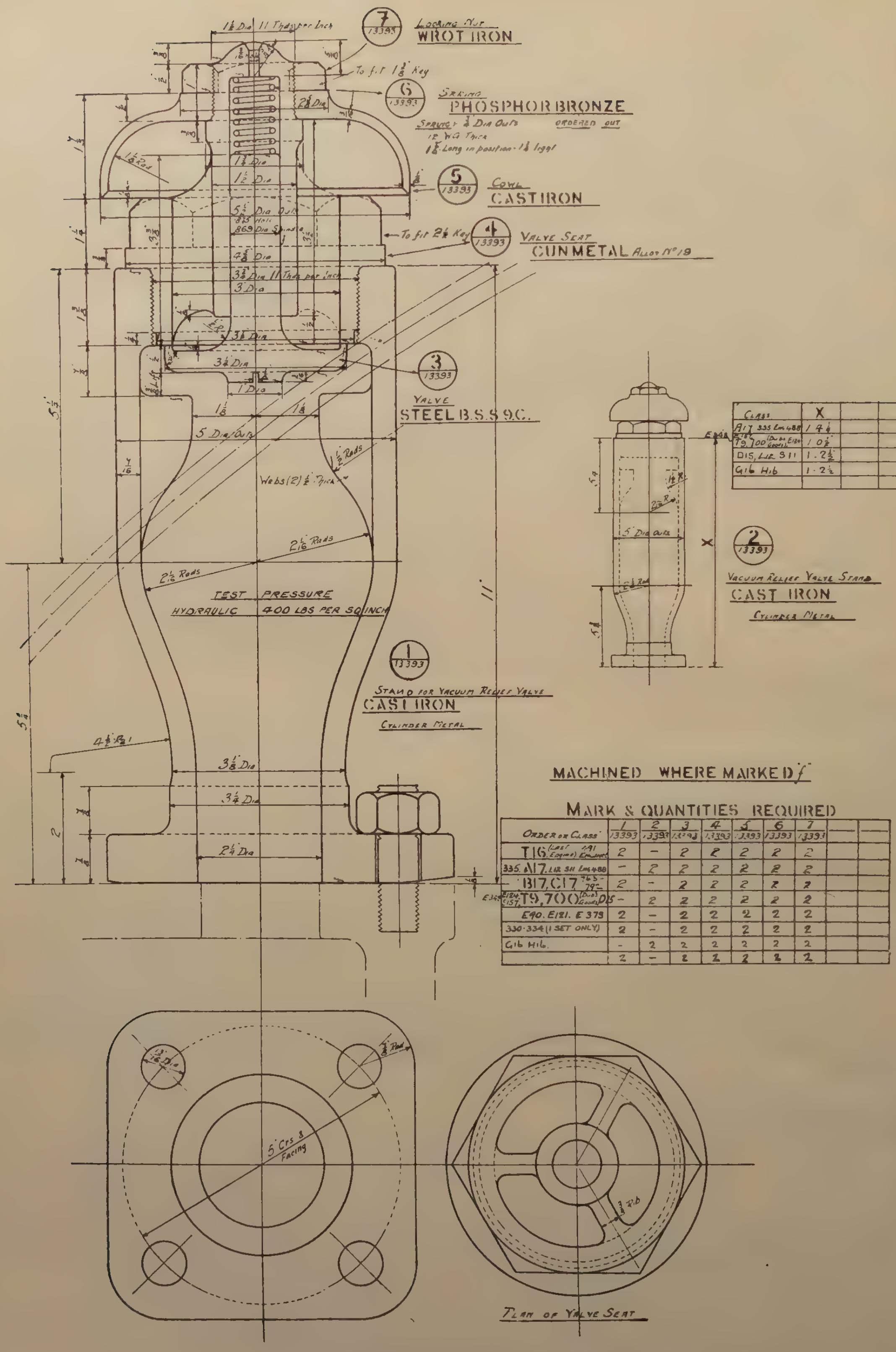


SECTION THRO' C D

| PART Nº | LETTER | DESCRIPTION | MATERIAL | CLASS OF WORK | Nº OFF PER SET | PATTERN Nº | WEIGHT EACH ROUGH | WEIGHT EACH FINISHED |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | C Q L | C Q L |
| | A | BYE PASS VALVE BODY | CAST IRON | MACHᴰ WHERE REQᴰ | 4 | | | 1 - 8 |
| | B | VALVE | · | · · · | 4 | | | 8 |
| | C | COVER | · | · · · | 4 | | | 13 |
| | D | JOINT RING | COPPER | · " " | 4 | | | 1 |
| | E | CYLINDER PLUG | STEEL C.L.B | · " · | 4 | | | 1LB 5OZS |

DIMENSION A IS TO BE DEFINITELY DECIDED BY TESTING ONE VALVE BEFORE CASTING REMAINING VALVES AND BODIES IN CASE THE CUSHIONING IS NOT SATISFACTORY THE DIMENSION MARKED A IS TO BE INCREASED IN ORDER TO MINIMISE THE HAMMER OF VALVE ON ITS SEAT AND YET MAINTAIN THE PROMPT SEATING OF THE VALVE. DIMENSION MARKED B TO BE $3\overset{3''}{\frac{1}{4}}$ DIA TO ALLOW REBORING IF NECESSARY.

eat Indian Peninsula Railway and East Indian Railway.


1⅛ Dia 11 Thds per Inch
7/13393 Locking Nut WROT IRON
To fit 1⅛ Key
6/13393 Spring PHOSPHOR BRONZE
Spring ⅞ Dia Outs 12 WG Thick 1⅜ Long in position · 1½ lg ??
Ordered out
2⅜ Dia
1½ Rad
1⅜ Dia
1½ Dia
5/13393 Cowl CASTIRON
5½ Dia Outs
.875 Hole .869 Dia Spindle
To fit 2¼ Key
4/13393 Valve Seat GUNMETAL Alloy No 19
4⅝ Dia
3⅞ Dia 11 Thds per Inch
3 Dia
3½ Dia
3¼ Dia
1 Dia
3/13393 Valve STEEL B.S.S 9.C.
1⅛
5 Dia Outs
Webs (2) ½ Thick
1½ Rads
2 1/16 Rads
TEST PRESSURE
HYDRAULIC 400 LBS PER SQ INCH
1/13393 Stand for Vacuum Relief Valve CAST IRON Cylinder Metal
4½ Rad
3⅛ Dia
3¼ Dia
2¼ Dia
5½
5¼
11
2
X
2/13393 Vacuum Relief Valve Stand CAST IRON Cylinder Metal
5 Dia Outs
13/16 Dia
⅜ Rad
5 Crs & Facing
⅜ Rib
Plan of Valve Seat

| Class | X | | |
|---|---|---|---|
| A17 335 Eng 488 | 1 4¼ | | |
| T9, 700 (Dub Goods) E124 | 1 0⅞ | | |
| D15, L12 311 | 1.2½ | | |
| G16 H16 | 1·2½ | | |
| | | | |

MACHINED WHERE MARKED *f*

MARK & QUANTITIES REQUIRED

| Order or Class | 1/13393 | 2/13393 | 3/13393 | 4/13393 | 5/13393 | 6/13393 | 7/13393 | | |
|---|---|---|---|---|---|---|---|---|---|
| T16 (Last 491 Engine) Engines | 2 | – | 2 | 2 | 2 | 2 | 2 | | |
| 335. A17. L12 311 Eng 488 | – | 2 | 2 | 2 | 2 | 2 | 2 | | |
| B17, C17 763–79– | 2 | – | 2 | 2 | 2 | 2 | 2 | | |
| E124, E157, T9, 700 (Dub Goods) D15 | – | 2 | 2 | 2 | 2 | 2 | 2 | | |
| E90. E121. E 379 | 2 | – | 2 | 2 | 2 | 2 | 2 | | |
| 330·334 (1 SET ONLY) | 2 | – | 2 | 2 | 2 | 2 | 2 | | |
| G16 H16. | – | 2 | 2 | 2 | 2 | 2 | 2 | | |
| | 2 | – | 2 | 2 | 2 | 2 | 2 | | |

Fig. 7. — Vacuum relief valve. — Southern Railway.

### 1. — *Number of engines fitted with feed water heaters.*

### 2. — *Names of makers of feed water heaters.*

1 and 2. — See table II hereafter.

TABLE II.

| RAILWAY. | Type A. | Type B. | | Type C. | | | | Type D. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Davies and Metcalfe. | Superheater. | Weir. | Elesco. | Coffin. | Superheater. | Worthington Simpson. | Weir. | Dabeg. | A. C. F. I. | Yamanato. |
| *South Manchuria* | ... | 11 | 1 | ... | ... | ... | 2 | 2 | ... | ... | ... | 11 |
| *Great Western* | ... | 1 100 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| *London Midland & Scottish* | ... | 130 | ... | ... | ... | ... | ... | ... | ... | 8 | ... | ... |
| *London & North Eastern* | ... | 1 250 | ... | 10 | ... | ... | ... | 3 | ... | 2 | 7 | ... |
| *Southern Railway* | ... | 234 | ... | ... | ... | ... | ... | ... | 54 | ... | ... | ... |
| *South African* | ... | 7 | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... |
| *Sudan Government* | ... | ... | ... | 24 | ... | ... | ... | ... | .. | ... | ... | ... |
| *New South Wales Government.* | ... | 470 | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... |
| *Canadian National* | ... | ... | ... | ... | 357 | 7 | .. | 113 | ... | ... | ... | ... |
| *Ceylon Government* | ... | 168 | ... | ... | ... | ... | ... | ... | ... | .. | ... | ... |
| *Madras & Southern Mahratta.* | ... | ... | ... | ... | ... | ... | ... | 1 | .. | ... | ... | ... |
| *South Indian* | ... | ... | ... | 13 | ... | ... | ... | .. | ... | ... | ... | ... |
| *Federated Malay States* | ... | ... | ... | 20 | ... | ... | .. | 2 | .. | ... | .. | ... |
| *Japan* | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| *Chosen* | ... | 3 | ... | ... | ... | ... | 1 | 1 | ... | .. | ... | ... |

### 3. — *Result of tests, giving coal and water consumption; average temperature of feed water when leaving the heater.*

*B type (Davies & Metcalfe).* — Tests reported generally seem to indicate a saving in fuel consumption of about 2 1/2 to 4 %, but one railway reports savings as high as 8 %.

The savings in water consumption are given as being about 10 % by one railway.

With this type, as with the D type, it

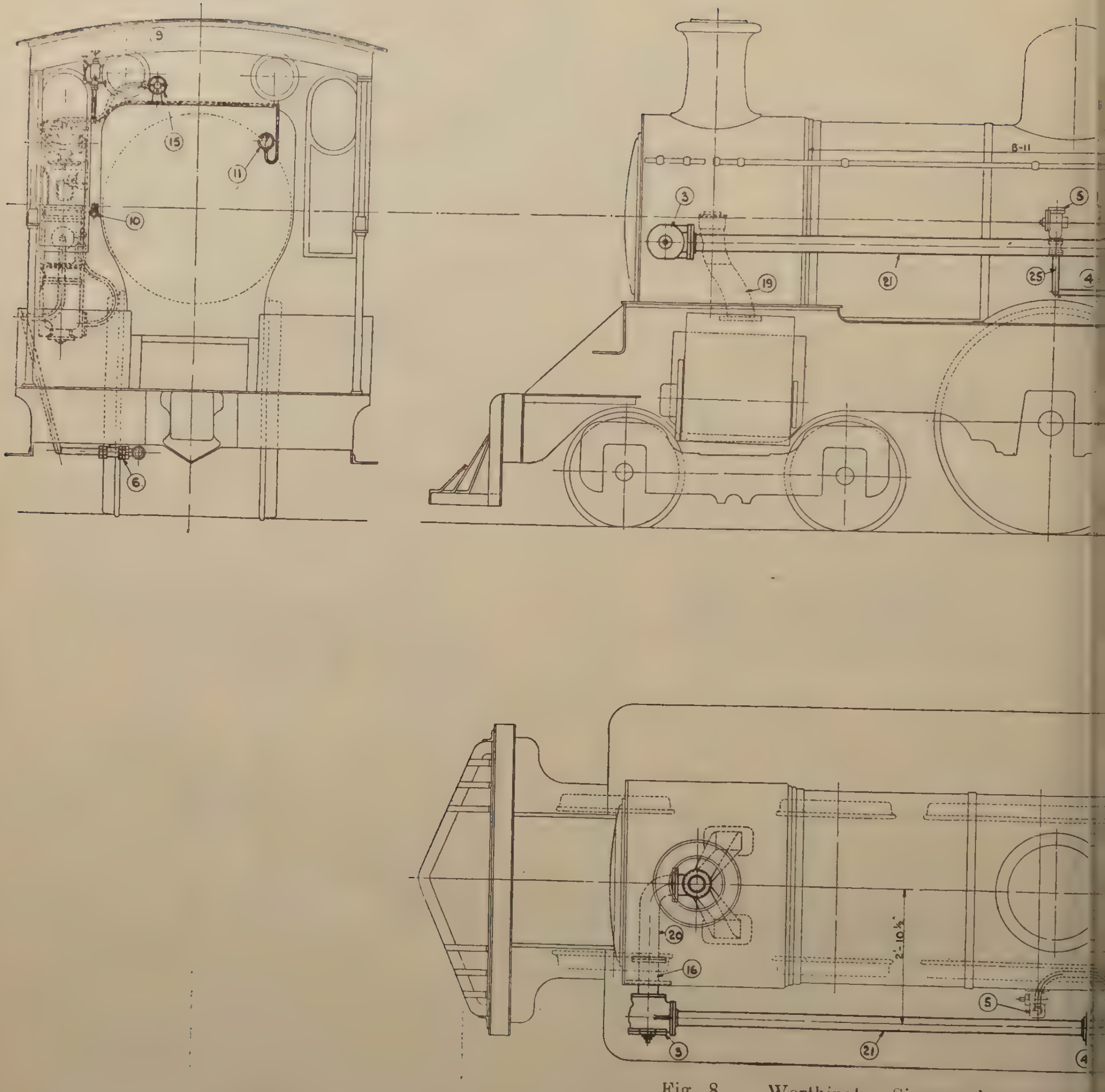
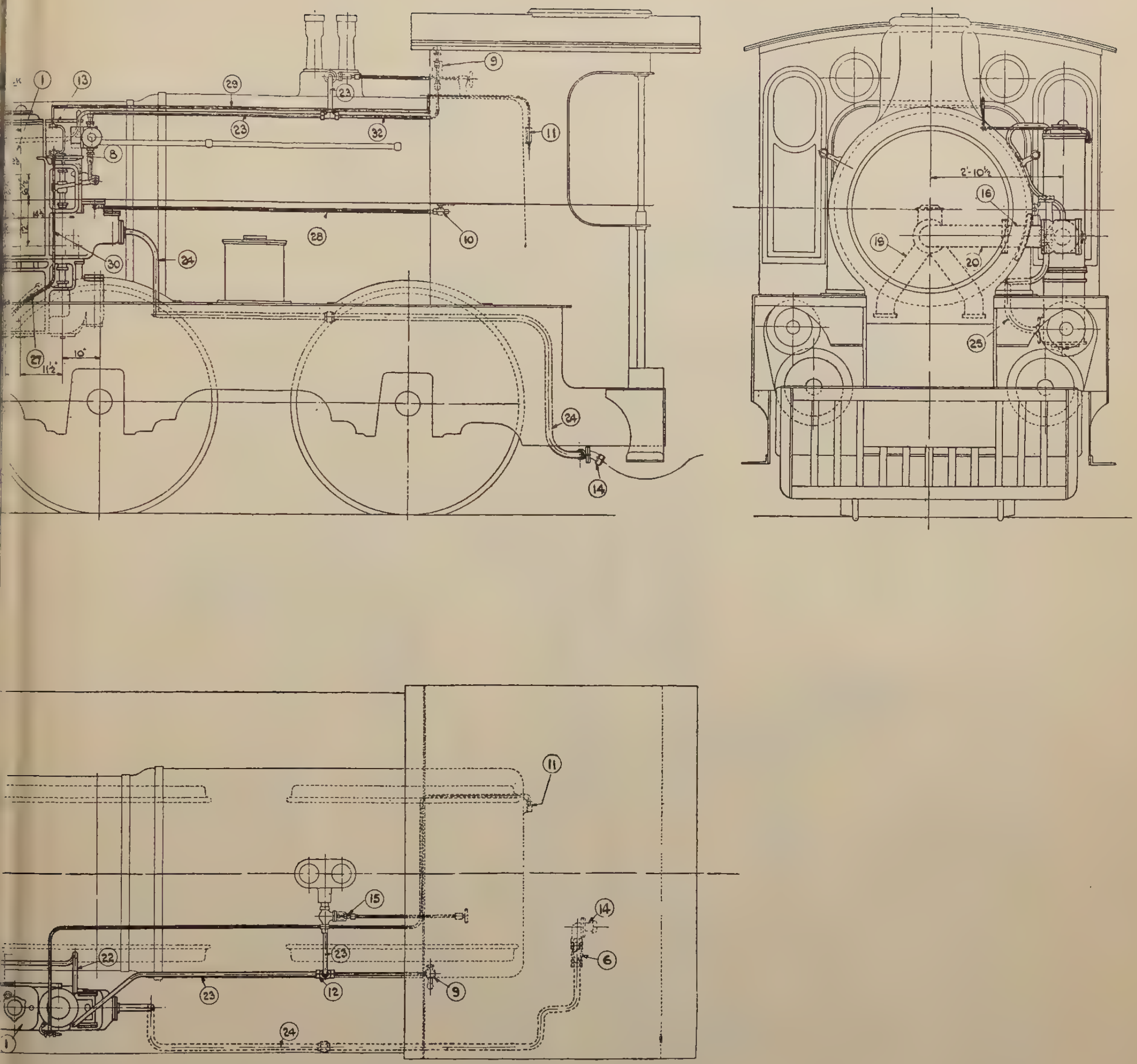


Fig. 8. — Worthington Simpson locomotive

| No. | *Description of parts.* | Int. diam. | *Remarks.* |
|---|---|---|---|
| 1 | Feed water heater and pump | ... | ... |
| 2 | Oil separator | ... | ... |
| 3 | Exhaust check valve | ... | ... |
| 4 | Expansion joint | ... | ... |
| 5 | Feed check valve | ... | ... |
| 6 | Check valve for feed pump suction | ... | Existing. |
| 7 | Relief valve | .. | ... |
| 8 | Automatic drain valve | ... | ... |
| 9 | Sight feed lubricator | ... | ... |
| 10 | Wash down cock | ... | .. |
| 11 | Pulsation gauge | ... | ... |
| 12 | Tee-piece | ... | Steam pipe to lubricator. |

| No. | *Description of pa* |
|---|---|
| 13 | Tee-piece |
| 14 | Hose coupling to tender |
| 15 | Steam valve and gear |
| 16 | Distance piece |
| 17 | Heater supports |
| 18 | Pipe supports |
| 19 | Blast pipe |
| 20 | Pipe from '16' to '19' |
| 21 | Exhaust steam pipe |
| 22 | Exhaust pipe from pump |



eater, Madras and Southern Mahratta Railway.

| Int. diam. | *Remarks.* | No. | *Description of parts.* | Int. diam. | *Remarks.* |
|---|---|---|---|---|---|
| ... | Gauge and drain. | 23 | Steam pipe to pump . . . . . . . . . . | 3/4" | ... |
| ... | Existing. | 24 | Pump suction pipe . . . . . . . . . . | 1 1/4" | ... |
| ... | ... | 25 | Pump delivery pipe . . . . . . . . . . | 1 1/4" | Lagged. |
| | | 26 | Separator drain pipe . . . . . . . . . . | 1/2" | ... |
| ... | do. | 27 | Air vent pipe (heater) . . . . . . . . . | 1/2" | ... |
| ... | ... | 28 | Wash down pipe to cab . . . . . . . . | 1/2" | ... |
| ... | ... | 29 | Pulsation gauge pipe . . . . . . . . . | 1/4" | .. |
| ... | .. | 30 | Steam cylinder drain pipes . . . . . . | 1/4" | ... |
| 4" | ... | 31 | | 1/4" | ... |
| 4" | Lagged. | | | and1/2" | ... |
| 1" | ... | 32 | Oil pipe from lubricator . . . . . . . . | 3/8" | ... |
| | | | | | ... |
| | | | | | ... |

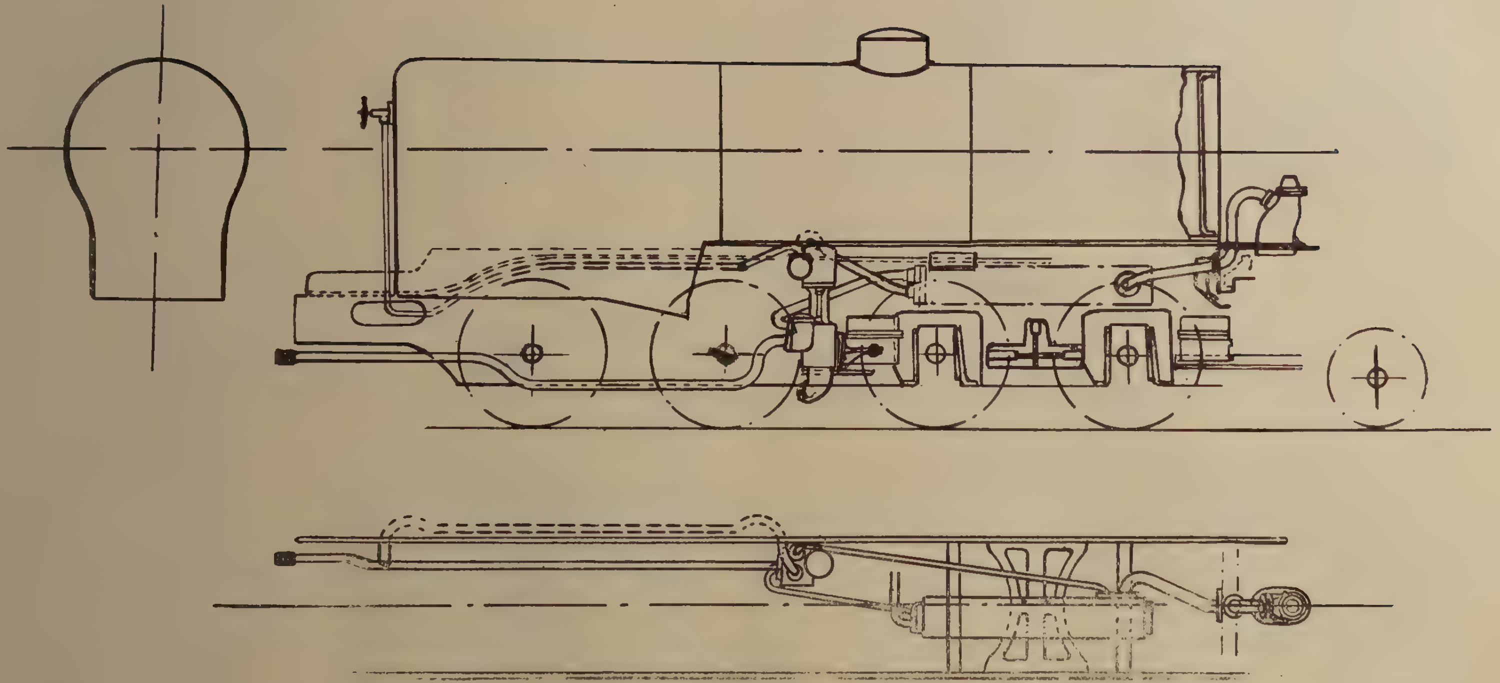


Fig. 9. — Arrangement of Weir feed water heater as used on the London & North Eastern Railway.

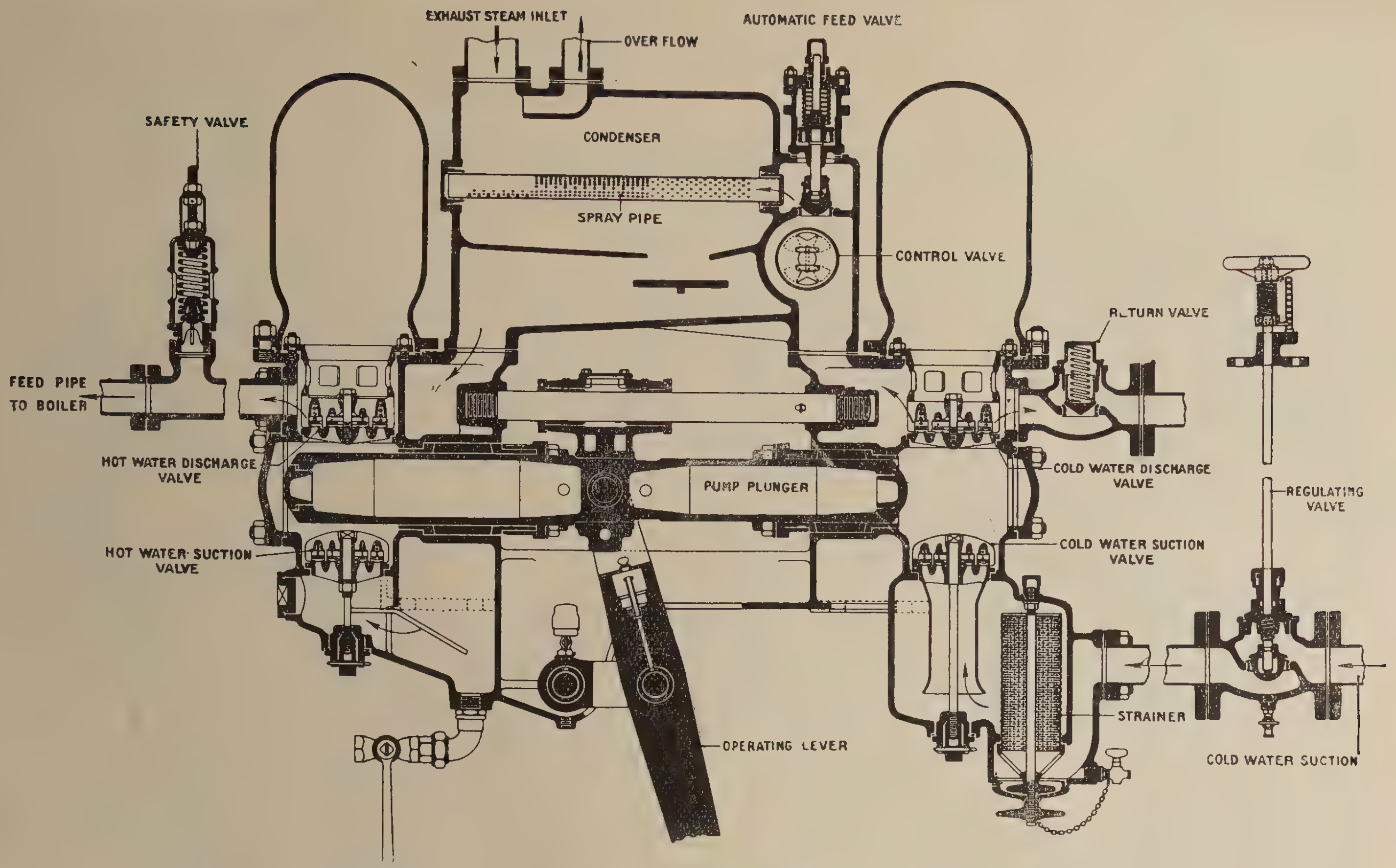


Fig. 10. — Dabeg feed water heater used on the London Midland & Scottish and London & North Eastern Railways.

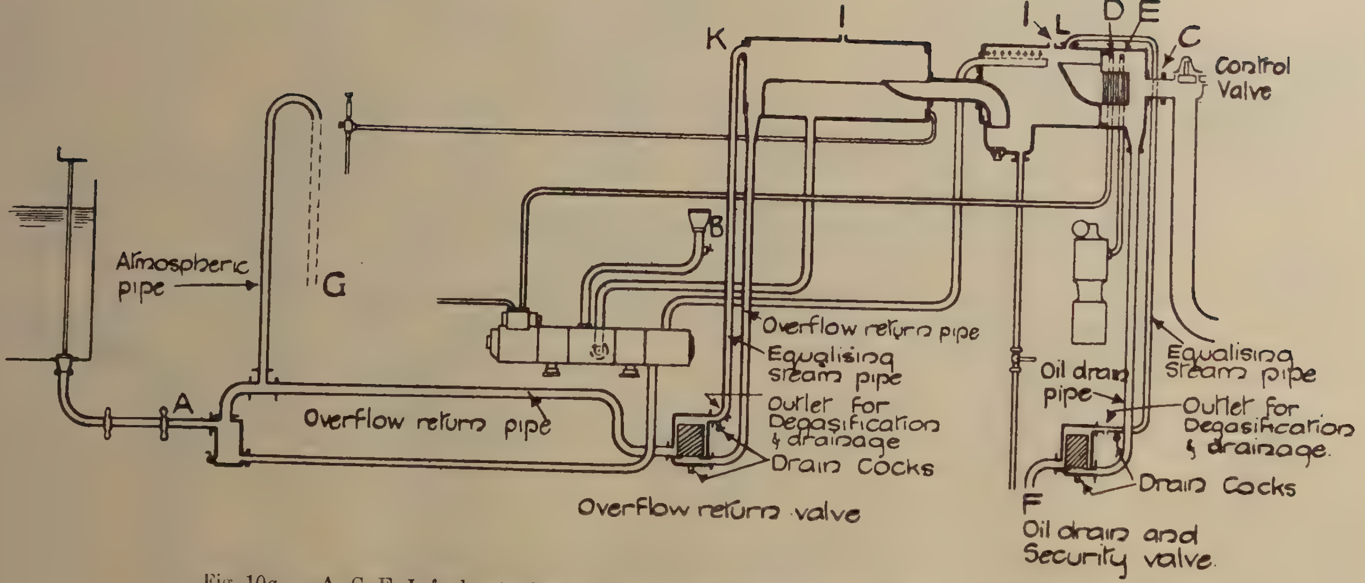


Fig. 10*a*. — A. C. F. I. feed water heater, Integral type, as fitted on the London & North Eastern Railway.

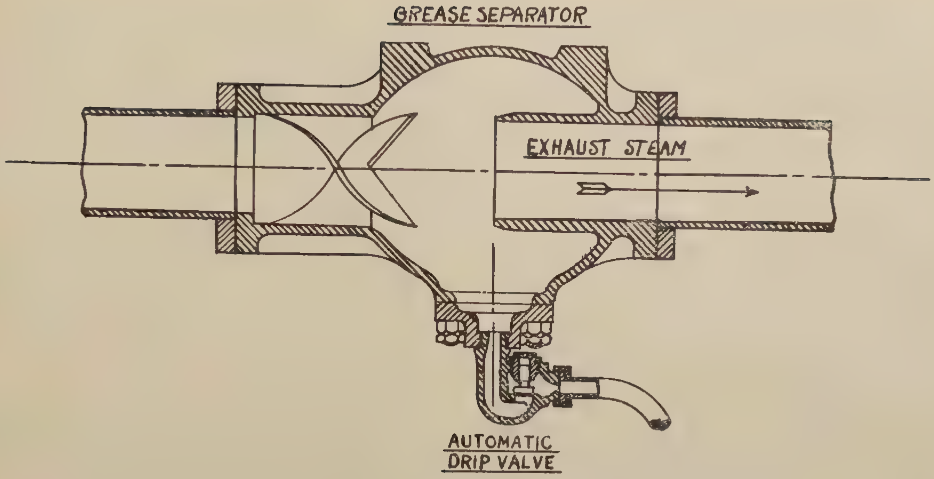


Fig. 10*b*. — Grease separator generally used with types B and D heaters.

can be reasonably expected that the saving in water will be greater than with the C type as all the exhaust steam which is condensed is added to the feed water.

*C type.* — The South Indian Railway report a saving in coal of 2 1/2 lb. per mile with heaters of the Weir type. It has been the general experience that whilst such feed water heaters give appreciable fuel economy when the tubes of the heater are clean, as they become coated with scale, there is a great falling off in the results obtained.

*D type.* — Feed water heaters of this type in which the exhaust steam comes into direct contact with the feed water give greater fuel savings than any other type. The London & North Eastern have carried out careful tests with the A.C.F.I. heater on express passenger engines on two sections of their railway and the results obtained indicate a saving in fuel of 8 to 10 % and a greater saving in water.

4. — *The influence of the heater on the partial softening of the feed water before its introduction into the boiler.*

Heaters of the D type have shown distinct advantage in removing temporary hardness and depositing scale in the body of the heater; also in freeing the feed water from gases inducive to pitting. This is due to the higher temperature attained by the feed water before it is forced into the boiler.

5. — a) *What type of oil separator is used with feed water heaters of type D ?*

b) *What amount of oil remains in the steam after passing through the separator ?*

c) *Has this led to any ill effects ?*

The type of oil separator generally used in heaters of the B and D types is shewn in figure 10*b*. No trouble due to oil getting into the boiler is reported by any railway.

6. — *Has trouble due to formation of scale in the tubes been experienced with heaters of type C ?*

Considerable trouble has been experienced by the formation of scale in the tubes of type C heaters.

7. — *Of the types of feed water heaters tested, which is preferred, with reasons.*

Of the feed water heaters tested so far, the most widely used is the Davies & Metcalfe exhaust steam injector which has the advantage of low first cost, low cost of fitting and maintenance, besides which it is light in weight and takes up little room. It requires a certain back pressure to operate it, and with the development towards improved valve gears and greater expansive use of the steam under similar working conditions, the injector requires some live steam to operate it. The fuel saving is not great, but the cost of upkeep is low, and it is reliable.

The Dabeg heater is well thought out and the mechanical drive is efficient; the equipment is bulky and heavy and in its present form is not readily applied to existing types of locomotives. Tests show it gives appreciable economy — of about 8 %. Difficulty was experienced with the valves in the case of six pumps of the original type when tried on the London Midland & Scottish. Two pumps of the latest type are now on trial on that railway, but the results are not yet available.

The A.C.F.I. heater is giving good results as regards fuel and water economy and has proved economical in maintenance. The improved Integral type of A.C.F.I. heater raises the temperature of the feed water higher than any of the other types.

The conclusion to be drawn is that the feed water heater has shown itself to be a valuable adjunct to the locomotive and that its use should become more general on locomotives.

## CHAPTER IV.

## Air pre-heating.

1. — *Give particulars of any air pre-heating arrangements in use and types of engines fitted.*

2. — *Results of tests.*

3. — *Effect on combustion, and whether it has been necessary to change the quality of fuel.*

4. — *Effect on maintenance and condition of the grate and firebox and tubes.*

5. — *Savings of fuel obtained .*

6. — *Cost of repairs.*

7. — *Increase of weight of the locomotive.*

No railway has reported the results of experiments on the pre-heating of air required for combustion.

# CHAPTER V.

## Valves and valve gears.

1. — *Give particulars of any improved form of steam admission valves and exhaust valves such as poppet valves, etc., introduced since 1922, and results obtained as regards :*

a) *Steam economy.*

b) *Reduction in maintenance.*

c) *Improved accessibility.*

2. — *Give particulars of any improved form of valve gear introduced since 1922, and give the following information :*

a) *Table of valve events as per Appendix II.*

b) *Results obtained and comparison made with locomotives fitted with the ordinary type of valve gear (in particular the influence of the valve gear on back pressure and exhaust and on the coal consumed).*

c) *Comparative cost of running maintenance.*

1 and 2. — The London Midland & Scottish report that in 1926 one of the 4-6-0 four-cylinder express engines of the « Claughton » type was fitted with Caprotti valve gear (see fig. 12). The results obtained were so satisfactory that 9 more engines of the same class have since been fitted.

Tests showed that a saving in the coal consumption of 22 % was obtained with the engine fitted with Caprotti gear as compared with engines of the same type and doing similar work, fitted with ordinary piston valves and Walschaerts gear. The Company points out that the coal consumption of the sister engines fitted with piston valves cannot be regarded as satisfactory.

The London & North Eastern report that they are fitting 2 express passenger engines of the four-cylinder 4-6-0 type with Caprotti valve gear.

Lentz poppet valves are being used in place of piston valves by several railways — generally the valves are being actuated by the ordinary Stephenson or Walschaerts gears. The London & North Eastern have 2 three-cylinder 4-4-0 type engines fitted with Lentz valves actuated by a rotating cam shaft. The cut-off can be varied by moving the shaft transversely, thereby bringing different cams in engagement with the rocker arms actuating the valves. When in mid gear the exhaust poppet valves are held open and so provide a bye-pass connecting each end of the cylinders. The steam valves, on the other hand, do not open at all when the engine is in mid gear.

The arrangement is shown in figures Nos. 11, 11*a*, 11*b*, 11*c*, and 11*d*.

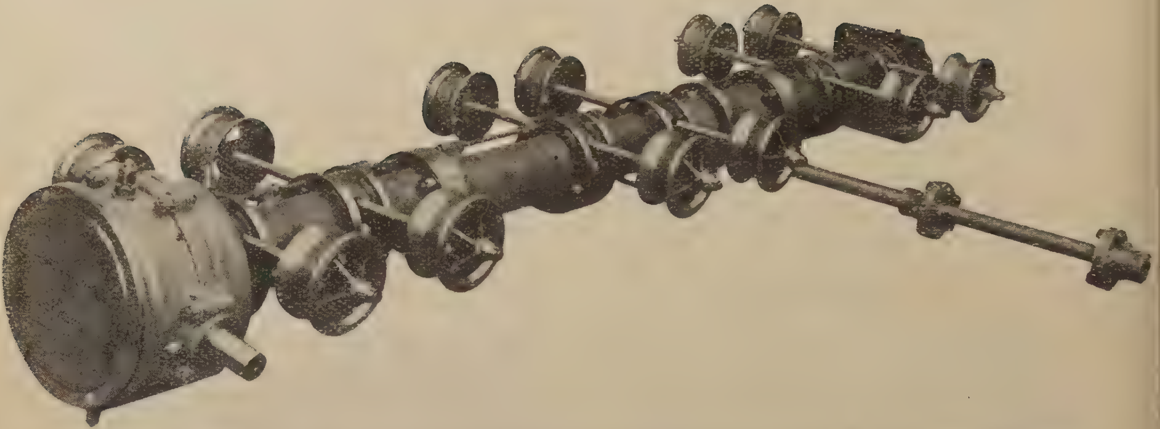


Fig. 11. — Assembly of rotary cam shaft and poppet valves, as used on the London & North Eastern Railway.

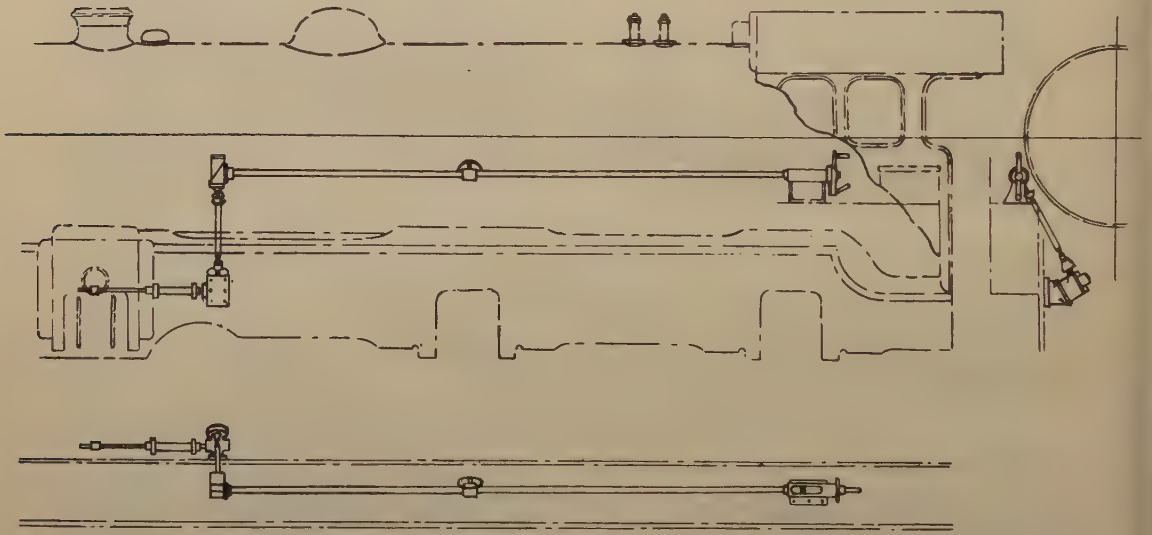


Fig. 11*a*. — Reversing gear arrangement for rotary cam valve gear as used on the London & North Eastern Railway.

*a*) Table of events.

Tables III and IV show valve events obtained by Caprotti and rotary valve gears.

*b*) Results of tests.

The London Midland & Scottish report a saving in coal consumption with Caprotti valve gear. The London & North Eastern has not had sufficient experience with rotary cam gear to give the economy in fuel obtained.

*c*) Improved accessibility.

Poppet valves are more easily removed

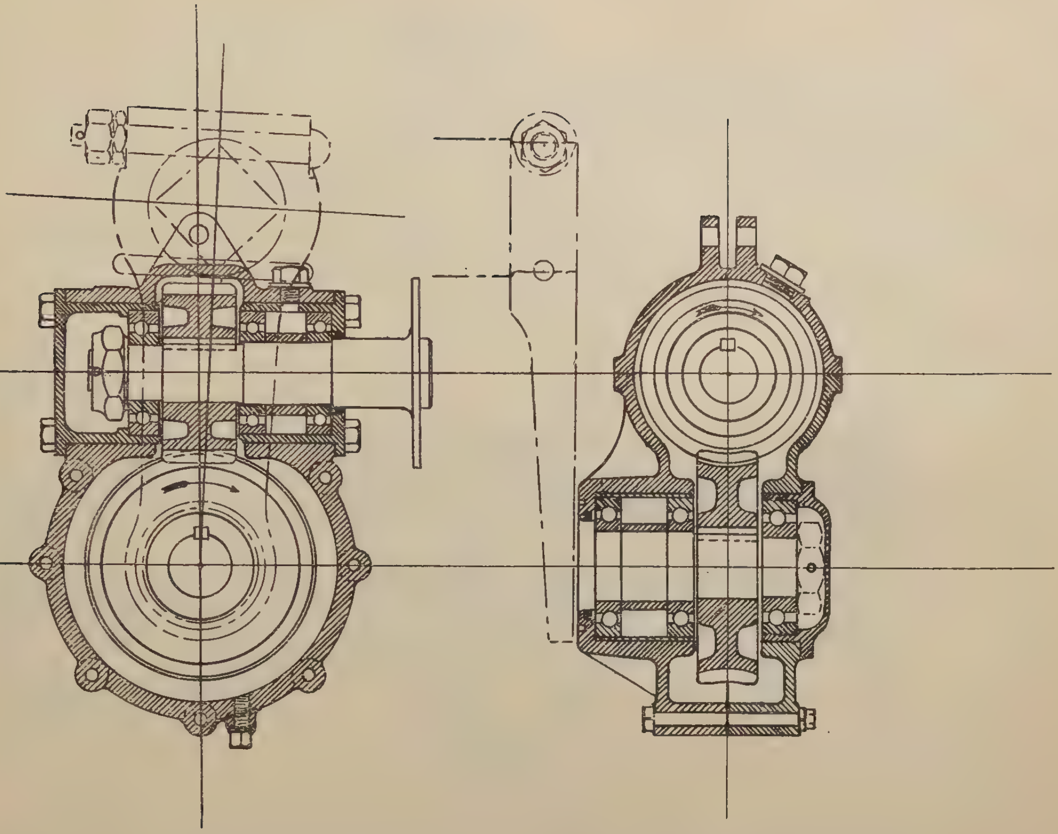


Fig. 11*b*. — Worm drive for rotary cam valve gear as used on the London & North Eastern Railway.

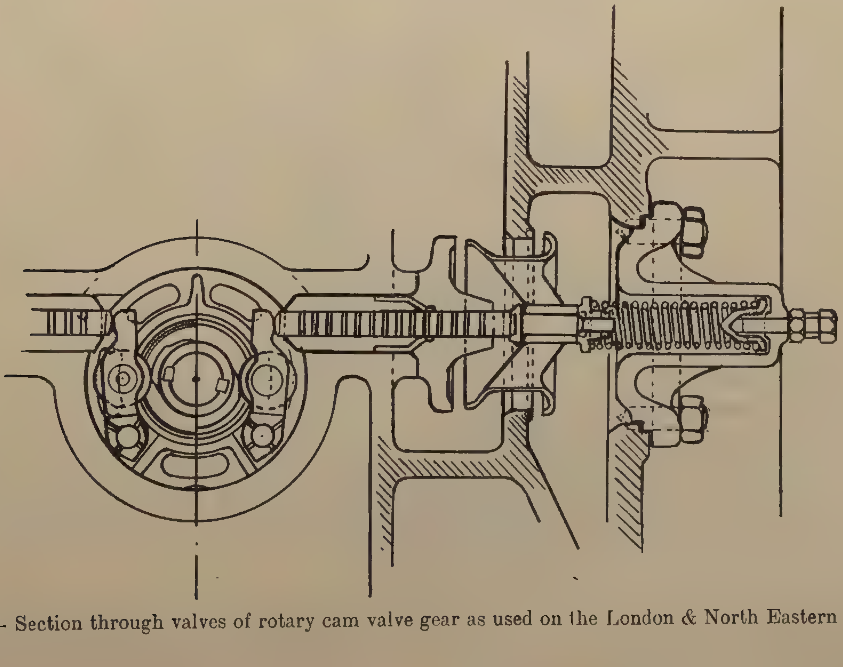


Fig. 11*c*. — Section through valves of rotary cam valve gear as used on the London & North Eastern Railway.

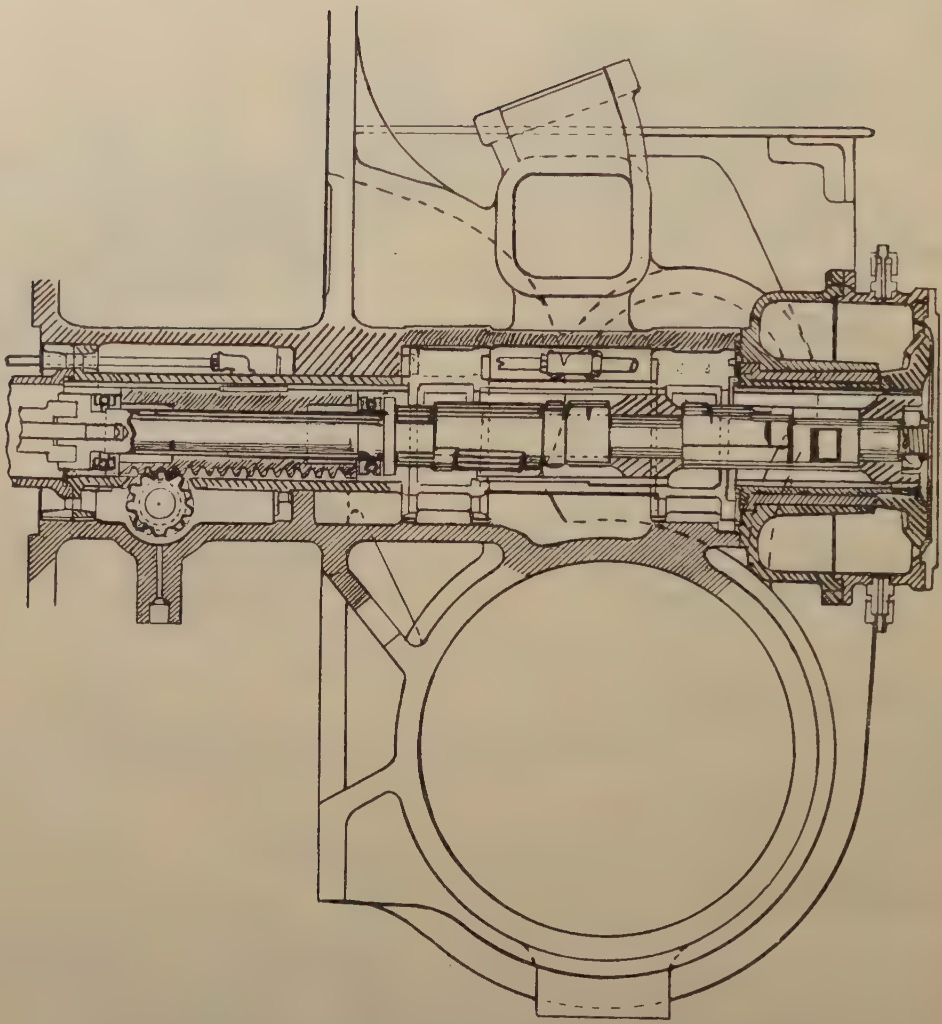


Fig. 11*d*. — Section through cylinders shewing rotary cam valve gear as used on the London & North Eastern Railway.

than piston valves and are not affected to the same extent by carbonisation of oil. Consequently, it is not necessary to examine poppet valves as often as piston valves. Experience so far obtained seems to point to lower maintenance cost of poppet valves than of piston valves.

Apart from the above no other new design of valves or valve gears have been introduced. There is a marked tendency on all sides to the adoption of more lap on valves and longer valve travel.

*Fig. 1.*

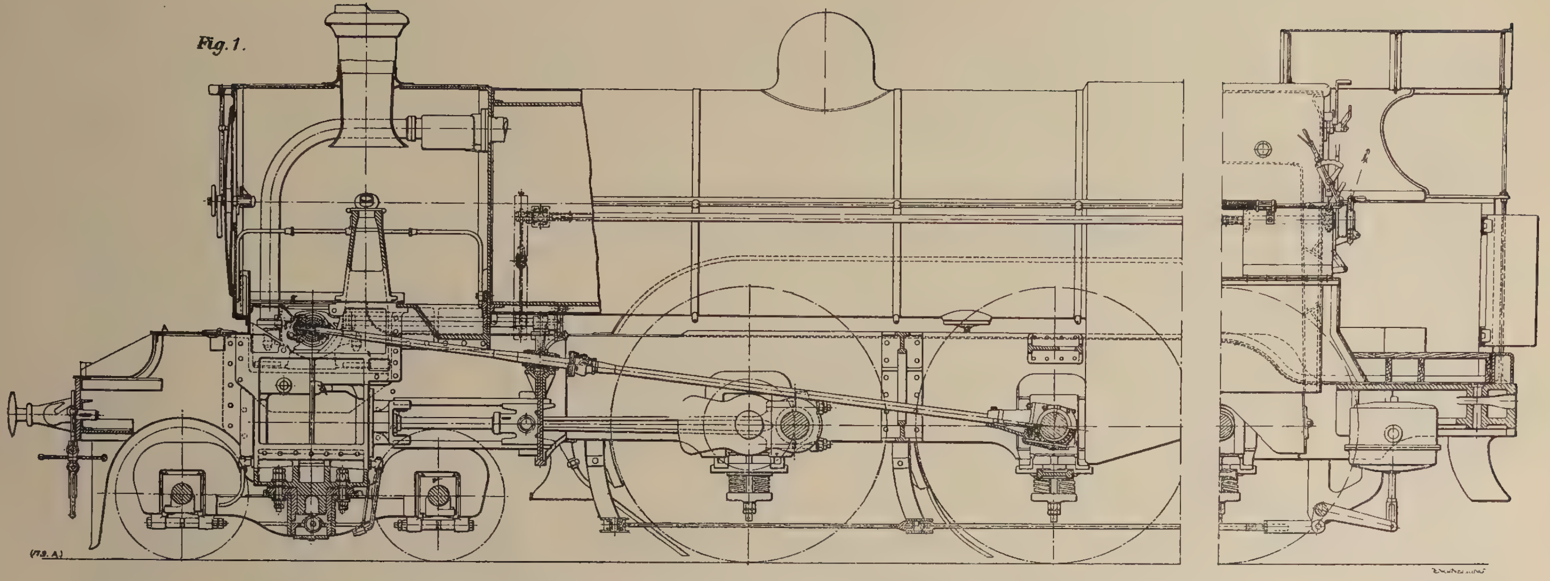


Fig. 12. — 4-6-0 type locomotive with Beardmore-Caprotti valve gear; London Midland & Scottish Railway.

## TABLE III.

### Valve events of Beardmore — Caprotti valve gear (poppet valve).

Number of cylinders: 4 — Diameter: 16 inches. — Stroke: 26 inches.

| Cylinder. | Cut off. | Preadmission, degrees. | | Lead, in inches. | | Valve opening, in inches. | | Cut off, °/o | | Exhaust port opening, in inches. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F. | B. | F. | B. | F. | B. | F. | B. | F. | B. |
| Outside | Full forward. | -14 | -14 | 0.25 | 0.25 | 0.645 | 0.67 | 81.0 | 79.0 | 0.954 | 0.954 |
| Inside. | Full forward. | -13 | -13 | 0.24 | 0.25 | 0.63 | 0.64 | 82.5 | 78.0 | 0.954 | 0.954 |
| Outside | 50 °/o | -14 | -14 | 0.25 | 0.25 | 0.645 | 0.67 | 51.0 | 49.0 | ... | ... |
| Inside. | 50 °/o | -13 | -13 | 0.24 | 0.24 | 0.63 | 0.64 | 52.5 | 48.75 | ... | ... |
| Outside | 30 °/o | -14 | -14 | 0.25 | 0.25 | 0.61 | 0.63 | 31.0 | 29.0 | ... | ... |
| Inside. | 30 °/o | -13 | -13 | 0.24 | 0.25 | 0.63 | 0.64 | 32.25 | 28.0 | ... | ... |
| Outside | 20 °/o | -19 | -19 | 0.359 | 0.359 | 0.55 | 0.59 | 21.0 | 19.0 | ... | ... |
| Inside. | 20 °/o | -18 | -18 1/2 | 0.312 | 0.359 | 0.55 | 0.59 | 22.0 | 18.0 | ... | ... |
| Outside | 10 °/o | -32 | -32 | 0.531 | 0.531 | 0.53 | 0.53 | 11.0 | 9.0 | ... | ... |
| Inside. | 10 °/o | -31 | -35 | 0.531 | 0.531 | 0.53 | 0.53 | 11.25 | 8.5 | ... | ... |
| Outside | Midgear. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Inside. | Midgear. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside | 30 °/o | -13 | -13 | 0.218 | 0.234 | 0.645 | 0.67 | 32.0 | 27.5 | ... | ... |
| Inside. | 30 °/o | -11 | -12 | 0.218 | 0.218 | 0.63 | 0.64 | 32.0 | 27.25 | ... | ... |
| Outside | Full back. | -13 | -13 | 0.218 | 0.234 | 0.64 | 0.62 | 81.0 | 78.0 | ... | ... |
| Inside. | Full back. | -11 | -12 | ... | ... | 0.63 | 0.64 | 82.25 | 77.5 | ... | ... |

TABLE IV.

## Valve events of Rotary cam gear.

Type of engine : 4-4-0 tender with poppet valves.
Number of cylinders : 3. — Diameter : 17 inches. — Stroke : 26 inches.

| Cylinder | Cut off. | Preadmission, °/o |  | Lead, in inches. |  | Valve opening. |  | Cut off. °/o |  | Exhaust opens, °/o |  | Exhaust port opening, in inches. |  | Exhaust closes °/o |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | F. | B. | F. | B. | F. | B. | F. | B. | F. | B. | F. | B. | F. | B. |
| Outside . . . . . | Full forward. | 2.25 | 1.5 | 0.24 | 0.26 | 0.497 | 0.496 | 74.75 | 68 | 91.5 | 88.5 | 0.614 | 0.621 | 13.5 | 11.5 |
| Inside . . . . . . | Full forward. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside . . . . . | 40 °/o | 2 | 1.5 | 0.242 | 0.260 | 0.491 | 0.485 | 41.5 | 36.25 | 92 | 88.25 | 0.618 | 0.623 | 14 | 11 |
| Inside . . . . . . | 40 °/o | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside . . . . . | 28 °/o | 2 | 1.75 | 0.246 | 0.272 | 0.491 | 0.493 | 30.25 | 24.75 | 83 | 76 | 0.613 | 0.623 | 27 | 22 |
| Inside . . . . . . | 28 °/o | ... | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside . . . . . | 20 °/o | 2 | 1.75 | 0.227 | 0.247 | 0.367 | 0.368 | 23 | 18 | 83 | 76 | 0.62 | 0.622 | 27 | 21 |
| Inside . . . . . . | 20 °/o | ... | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside . . . . . | 10 °/o | 1.75 | 1.5 | 0.128 | 0.129 | 0.139 | 0.135 | 12.5 | 9 | 83.25 | 77 | 0.42 | 0.44 | 27 | 19 |
| Inside . . . . . . | 10 °/o | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside . . . . . | Mid gear. | Steam valves completely shut. |  |  |  |  |  |  |  | Exhaust valves open 1/4" (bye-pass). |  |  |  |  |  |
| Inside . . . . . . | Mid gear. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Outside . . . . . | 30 °/o | 2 | 0.75 | 0.121 | 0.095 | 0.50 | 0.498 | 35 | 28 | 86.25 | 82.5 | 0.625 | 0.627 | 24 | 16.5 |
| Inside . . . . . . | 30 °/o | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Outside . . . . . | Full back. | 2.5 | 1.00 | 0.129 | 0.102 | 0,512 | 0.510 | 81 | 75 | 94 | 92 | 0.624 | 0 627 | 9.75 | 5.5 |
| Inside . . . . . . | Full back. | ... | ... | ... | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... | ... |

# CHAPTER VI.

## Arrangement of front end.

1. — *Submit drawing of standard smokebox layout showing chimney and exhaust pipe and relative positions.*

The drawings sent in by the Railway Companies replying to the questionnaire show that there is no standard design of front end, each type of engine having the dimension of chimney petticoat pipe and blast pipe diameter and height found to give the best results.

2. — *Give particulars of any experimental blast pipe arrangements in use.*

The only railways reporting experiments with front end arrangements are the London & North Eastern and London Midland & Scottish Railways, both of which Companies have made experiments with the Kylala arrangement of blast pipe. The London & North Eastern Railway originally fitted up a 4-4-0 express passenger locomotive with a Kylala blast pipe. Good results were obtained both as regards free steaming and easy running, the latter due to a reduction in back pressure. Further tests are being carried out on two 4-4-0 express passenger engines with the Kylala-Chapelon arrangement as developed on the Paris-Orleans. Reports state that equally good results are forthcoming but no actual figures of any fuel savings are yet available. Figure 13 shows the latest application of the above blast pipe.

*Give results of experiments on :*

a) *Smoke box vacuum.*

In this connection it is of interest to report the results of trials in smokebox vacuum carried out on the London & North Eastern Railway with special recorders manufactured by the Cambridge Instrument Company on three-cylinder locomotives and two-cylinder locomotives.

Although smokebox vacuum is usually measured in inches of water, a water-gauge cannot be used if it is desired to find out the actual vacuum produced at each exhaust-beat, as the inertia of the moving column of water would cause the readings to be quite inaccurate at low speeds and not sufficiently responsive at high speeds. To analyse the exhaust-beats of a three-cylinder freight engine with 56-inch wheels running at 30 miles per hour requires an apparatus sufficiently sensitive and free from inertia as to be able to respond to fluctuations of the order of 1 100 per minute. A draught-recorder that fulfilled these conditions was obtained from the Cambridge Instrument Company. It was based on the principle used in the Collins indicator, in which the diagram is traced by a steel point on a celluloid film, the movement being kept very small to avoid inertia effects.

The recorder consisted of a corrugated steel diaphragm, one side of which was in communication with the interior of the smokebox and the other under atmospheric pressure. The movement of the diaphragm was constrained by a stiff flat spring. A steel point at the top of this spring traced a line on a moving celluloid ribbon. The deflection of the spring was proportional to the draught induced by the blast, and a microscope fitted with a graduated eye-piece was used for reading the vacuum obtained. A further steel point actuated by an electro-magnet enabled time or revolutions to be marked on the ribbon.

The two and three-cylinder 2-8-0 engines previously referred to were tested with this instrument. It was fitted to the side of the smoke-box at the end of a straight pipe of 1-inch bore; the pipe extended to the centre of the smoke-box, the height being 1 inch below the blast-pipe top and 15 inches behind it, this distance being intermediate between the blast pipe orifice and the tube-plate. The orifice was 5 1/4 inches diameter, and at the same height in each case, and all other smoke-box conditions were equal.

In taking comparative records with the two engines, speeds, steam-chest pressures, and cut-offs were kept alike as near as possible, the ash-pan dampers were open, the fire-doors in the same position, and no records taken when firing. The state of the fire was kept as uniform as possible, but an oil-fired locomotive would be the only means of eliminating this variable. Varying the resistance to the passage of air into the firebox affects the draught produced — for example, closing the dampers immediately increased the vacuum by 2 inches.

The Author is not yet able to give as much information as he would like, as the apparatus is still in the experimental stage, but the following results may be of interest. At slow speeds when working hard, at the instant when steam escapes from the blast-pipe, there is a small plenum in the smoke-box; it is followed instantly by the greatest vacuum which returns again to zero before the next impulse. At 3 miles per hour the greatest vacuum with the two-cylinder engine was 10 inches and 7 inches with the three-cylinder preceded by pressures of 1 inch and 1/2 inch respectively.

There is about the same variation at more normal running speeds when the engines are working hard. For example, the two-cylinder engine showed a vacuum of 10 1/2 inches falling to 1 inch between impulses when running at 15 miles per hour, 47 % cut-off and 145-lb. steam-chest pressure. The three-cylinder engine with the same cut-off and steam-chest pressure at 16 miles per hour showed a vacuum of 7 inches falling to zero between impulses.

It was not anticipated that there would be much variation at high speeds, as the impulses would follow so rapidly that there would be no time for the vacuum to drop. At 30 miles per hour the time between impulses is only 1/12 of a second with the two-cylinder engine, and it was expected that the gases would be flowing through the tubes so quickly that the fluctuations shown at slow speeds would almost disappear.

Contrary to expectation, however, the fluctuations are still maintained, not so extensive, but still there is quite a large drop after each impulse. For example, at 30 miles per hour with 110 lb. in the steam-chest and at 47 % cut-off, the vacuum with the two-cylinder engine rose to 8 1/2 inches at the instant of exhaust and fell to 3 inches before the next im-

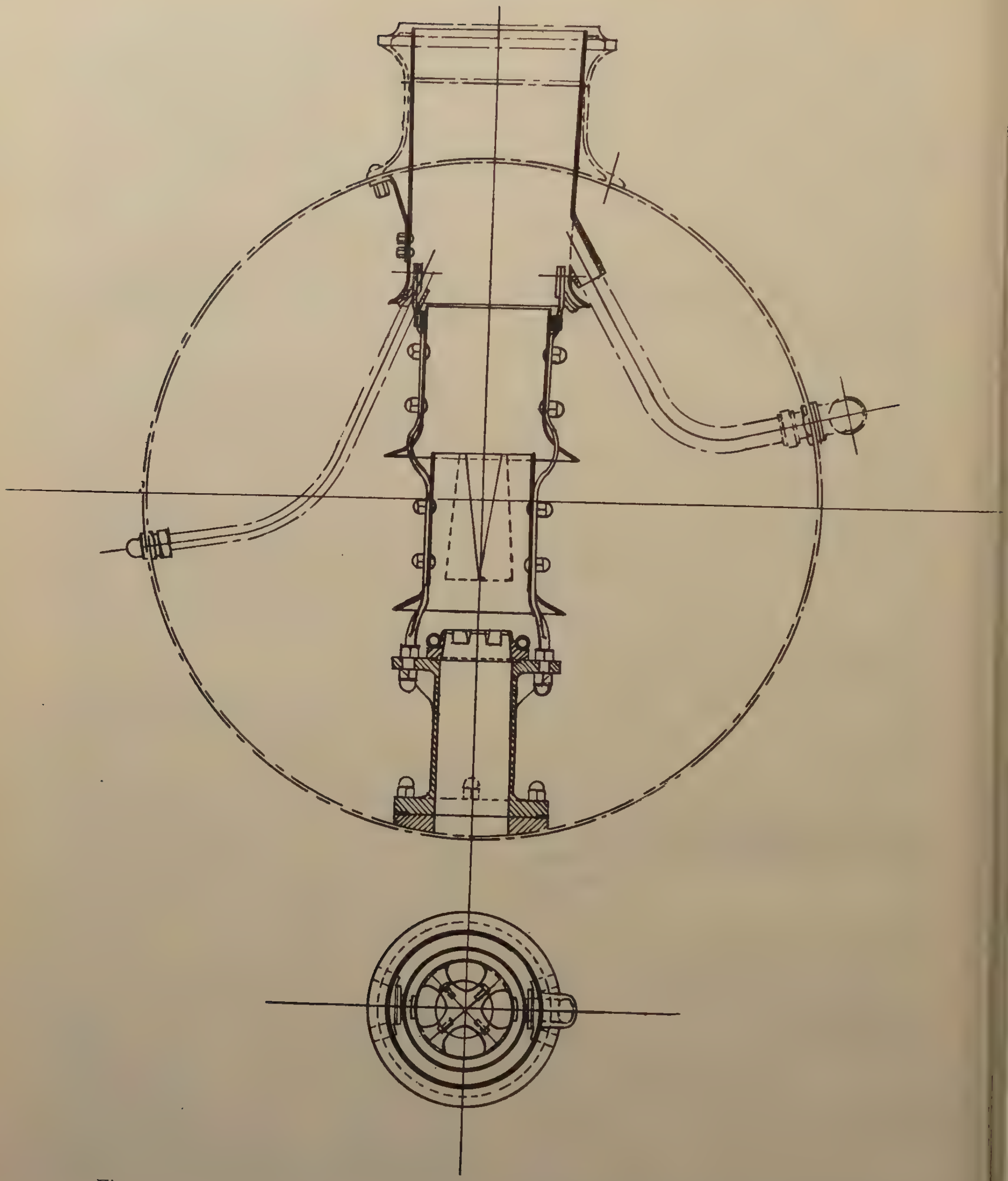


Fig. 13. — Latest application of Kylala blast pipe on London & North Eastern Railway.

pulse. The three-cylinder engine, under exactly similar conditions, showed a vacuum of 6 inches falling to 1 1/2 inches before the next impulse, the period between successive impulses being only 1/18 of a second.

Typical diagrams of smokebox and firebox vacua obtained with a Cambridge recorder are reproduced in figure 14.

b) *Size of chimney and petitcoat pipe;*

c) *Height of top of blast pipe nozzle above or below centre line of boiler;*

d) *Height of chimney at smallest diameter above centre line of boiler;*

e) *Have any modifications been made to the front end to prevent steam being beaten down along the barrel ?*

The only railways reporting any special device to prevent smoke beating down on the boiler are the London Midland & Scottish which has fitted scoops behind the chimney, and the Southern which is fitting vertical plates on both sides of the smokebox. The latter arrangement is stated to have effected the desired result; the former has also resulted in some improvement (see photograph, fig. 15).

With modern locomotives working at early cut-off the back pressure is so low that the smoke is not lifted clear of the boiler and it is to be expected that fittings as the above or some re-design of the front end will be needed to overcome the difficulty.

## CHAPTER VII.

## Miscellaneous.

### A. — Compounding.

1. *What system of compounding, if any, has been made standard and give particulars as follows :*

a) *Number of H. P. and L. P. cylinders.*

b) *Ratio of diameters.*

c) *Volume of clearance space.*

d) *Valve gears used either joint or separate.*

e) *Cut off in H. P. and L. P. cylinders. (Is this fixed or can it be varied ?)*

f) *Steam pressure used.*

2. *Give results of any trials and especially :*

a) *Saving of fuel.*

b) *Saving of water.*

c) *Effect on maintenance cost.*

3. — *Give particulars of maintenance and first cost.*

4. — *Are experiments being made with any new arrangement of cylinders and valve gears ? If so, give particulars.*

5. — *Have experiments enabled any definite decision to be made in favour of either the compound or the simple engine ?*

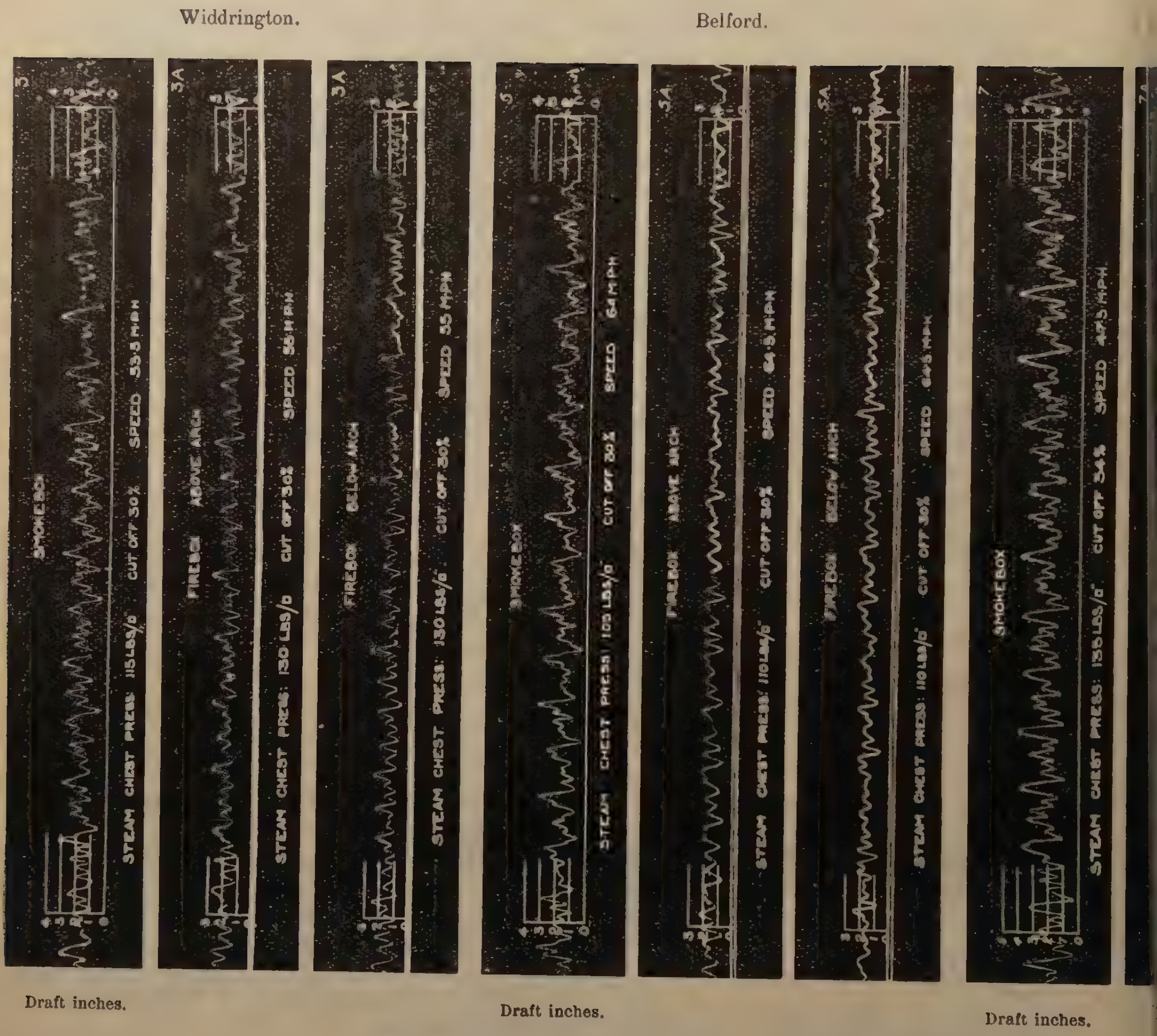
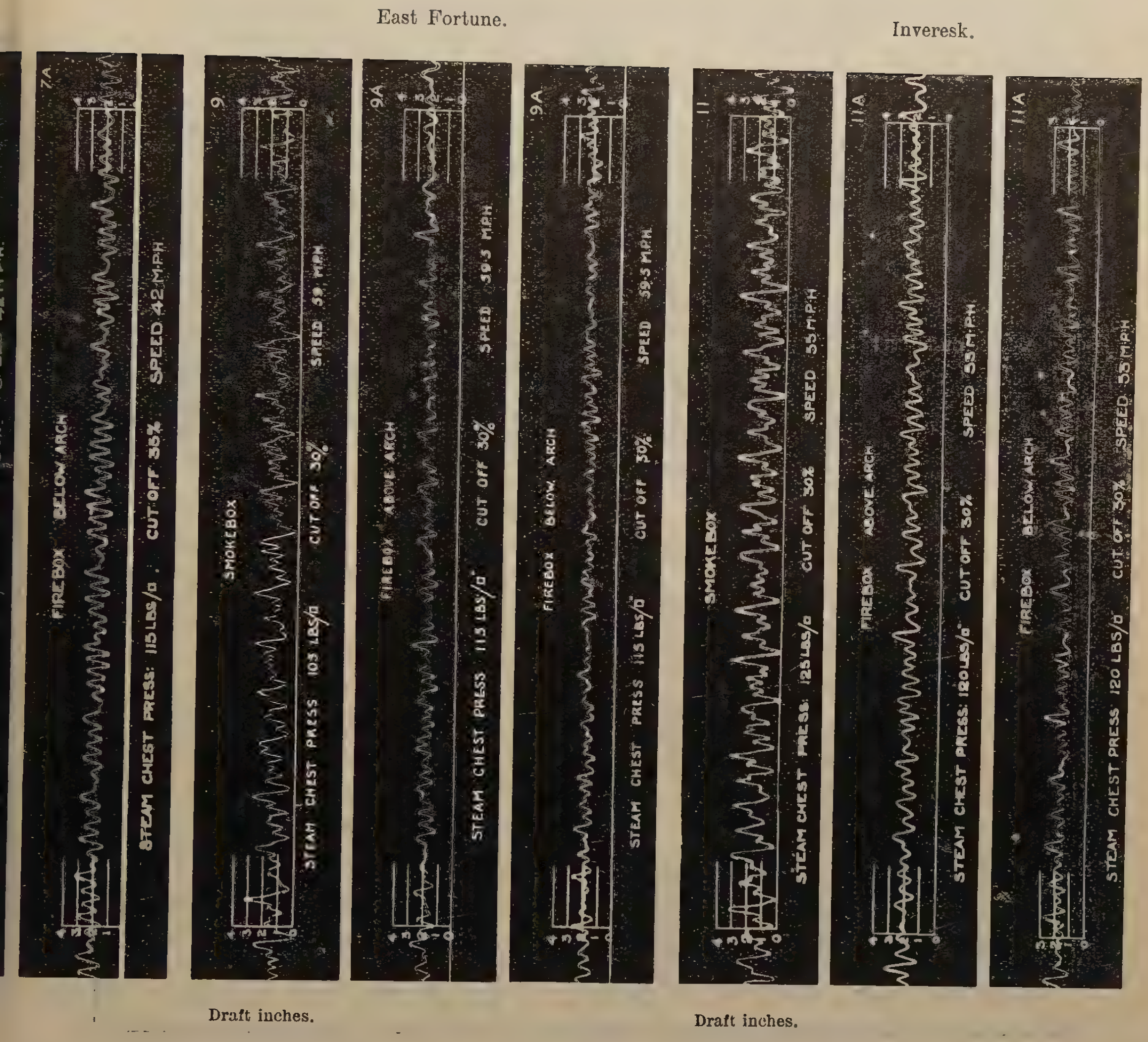


Fig. 14. — Comparative smokebox and f

6. — *If intermediate superheating is being done, give particulars of arrangements and results.*

The replies shew that compounding is not being extended except on a few railways using Mallet engines. Results with compound engines have been reported at previous meetings of the Congress and there is no useful information to add to that already given in the *Bulletin*.



a, engine 2574, type A1, August 1927.

The only trials that have been carried out recently by any railway reporting were on the London Midland & Scottish when 3-cylinder *compound* 4-4-0 engines were tested against 2-cylinder 4-4-0 engines and gave definitely better results, details being shown in the following table.

Dynamometer car tests between Carlisle & Preston. — May 1925.

| — | Engine No. 90. (Prince of Wales.) | Engine No. 1065. (Compound). |
|---|---|---|
| Weight of train with dynamometer car, in tons | 322.7 | 326.4 |
| Total weight of engine, car and train, in tons | 421.6 | 423.8 |
| Ton-miles excluding engine | 29 090.7 | 29 450.7 |
| Ton-miles including engine | 38 018.0 | 38 396.0 |
| Average speed, miles per hour | 50.6 | 51.15 |
| Average drawbar pull, in tons | 1.88 | 2.09 |
| Total work done by engine, in horse power-hours | 784.62 | 860.7 |
| Average drawbar horse power | 526.9 | 612.7 |
| Maximum drawbar horse power | 778.0 | 867.0 |
| Horse power hours per train mile | 8.7 | 9.53 |
| *Water.* | | |
| Pounds per ton-mile, including engine | 0.678 | 0.657 |
| Pounds per draw bar horse power-hour | 33.0 | 29.2 |
| *Coal.* | | |
| Pounds per mile | 44.17 | 40.7 |
| Pounds per ton-mile (excluding engine) | 0.137 | 0.125 |
| Pounds per ton-mile (including engine) | 0.104 | 0.096 |
| Pounds per draw bar horse power-hour | 5.07 | 4.27 |
| Average per square foot of grate area (in lb.) | 89.6 | 73.4 |

No experiments on intermediate superheating have been reported.

Compounding within the normal ranges of pressure appears to be of little value. With the use of higher pressures the advantages of compounding are more apparent.

### B. — Combustion in fireboxes.

1. — *Please give particulars and results of any experiments on :*

a) *Ash-pan openings.*

From replies received it appears to be

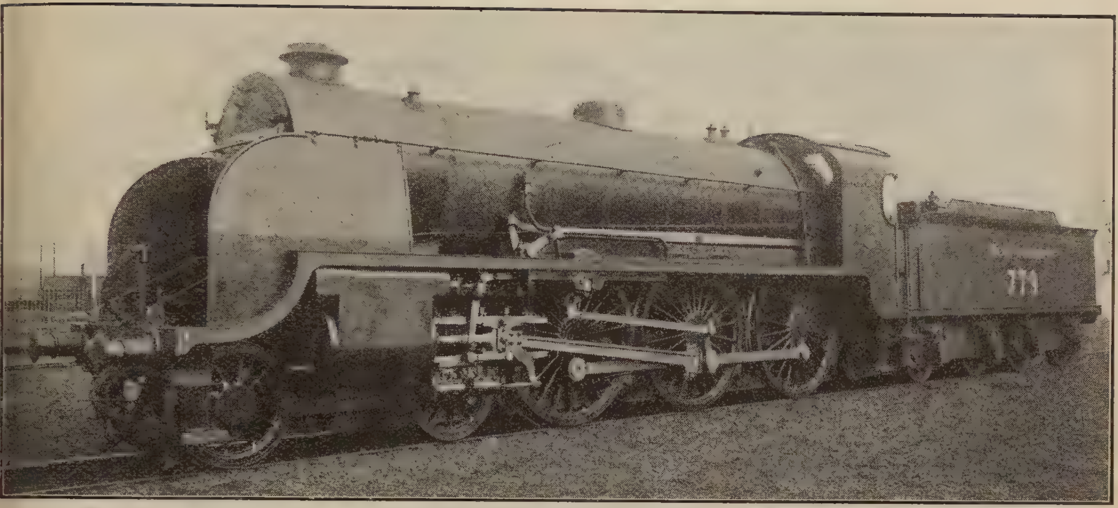


Fig. 15. — Arrangement of smoke deflector; Southern Railway.

generally accepted that the ash-pan openings shall be 15 % of the grate area.

b) *Grate openings or firebar spacing or special type of firebar.*

The air space through the grate openings between the firebars is roughly 35 % of the grate area.

Rocking grates are used on many railways. The space between the firebars varies from a minimum of 3/16 inch up to 1 1/8 inches. The quality and size of the coal to be burnt is the ruling factor in the spacing of firebars. The use of drop grates is increasing and is of advantage in cleaning and dropping fires.

c) *Brick arches.*

No novel feature in connection with brick arches has been reported.

d) *Supplementary air through arch.*

No reports have been received of the use of any arrangement whereby air is introduced above the fire through the brick arch.

e) *Brick arch tubes.*

See replies to *c*).

f) *Supplementary air through back-plate.*

No railway reports the provision of special openings through the back of the firebox to give a supplementary air supply. The London Midland & Scottish report the trial of the Langer system of combustion control whereby steam is blown into the firebox with a view of improving the turbulence in the firebox, particularly at the sides. This system is extensively used on the Austrian State Railways.

The conclusion to be drawn from the replies is that the usual arrangement of ash-pan and dampers, brick arch, and firehole door meets all requirements and gives good results, and that future alterations will be in the direction of making it easier to empty the firebox and clean the ash-pan by drop grates and self-emptying ashpans.

### C. — Circulation in boilers.

*Has any device been tried to improve the circulation of the water in the boiler such as :*

*Arch tubes, thermic syphons, etc.*

*Give results of tests, and give particulars of effect on the first cost and cost of maintenance.*

*Effect on boiler cleanliness.*

*Any economies resulting.*

*Particulars of any increase in boiler capacity.*

Replies were received from thirteen railways who stated that they were using arch tubes or thermic syphons.

No figures were available as to the tests nor were any figures given as to cost of maintenance.

No replies were received as to the effect on boiler cleanliness.

It would appear that such devices tend to complicate the boiler construction and it would seem that their use is only justified under special circumstances.

Strictly comparative tests over a lengthy period of boilers with and without such devices, taking into account all fitting and maintenance costs, would be of interest.

### D. — Regulators.

*Describe any new arrangement of regulator adopted since 1922, and attach the necessary explanatory drawings.*

*Give particulars of any improvement obtained both as regards ease and accuracy of control, steam tightness and freedom from wear.*

*Have regulators controlling the steam on the superheated side been tried, if so, describe arrangement and give particulars of any additional stop cock on saturated side fitted. What has been the practical result of this arrangement, both as regards the regulator proper and as regards the superheater elements ?*

From replies received, it would appear that there is a marked tendency towards regulators of the double beat balanced type. Three types of this regulator are shown in figures 16, 17 and 18.

Another type recently introduced is the application of a throttle to the superheated side of the steam by incorporating the regulator in the superheater header. Figure 19 shows an application of this regulator by the London & North Eastern.

Results with this type of regulator show that it has ease and accuracy of control and is easily accessible. No results as to its effect on the elements of the superheater are given.

### E. — Steam dryers or separators.

*Describe any arrangement of steam dryer which has been tried, and attach the necessary explanatory drawings.*

*Give particulars of any test that has been made to ascertain the reduction in the amount of water present in the steam thrown out by such dryers.*

*Give particulars of any tests made to determine the effect of such steam dryers on superheat and fuel consumption.*

*Has the use of such separators had any effect on the life of the superheater elements ?*

Three railways report experiments with steam dryers, but without success. The failure is probably due to lack of space, and to the intermittent demands on the boiler.

Superheater elements shew water erosion at the bends from the saturated heater, and there is therefore need of some means of removing the entrained

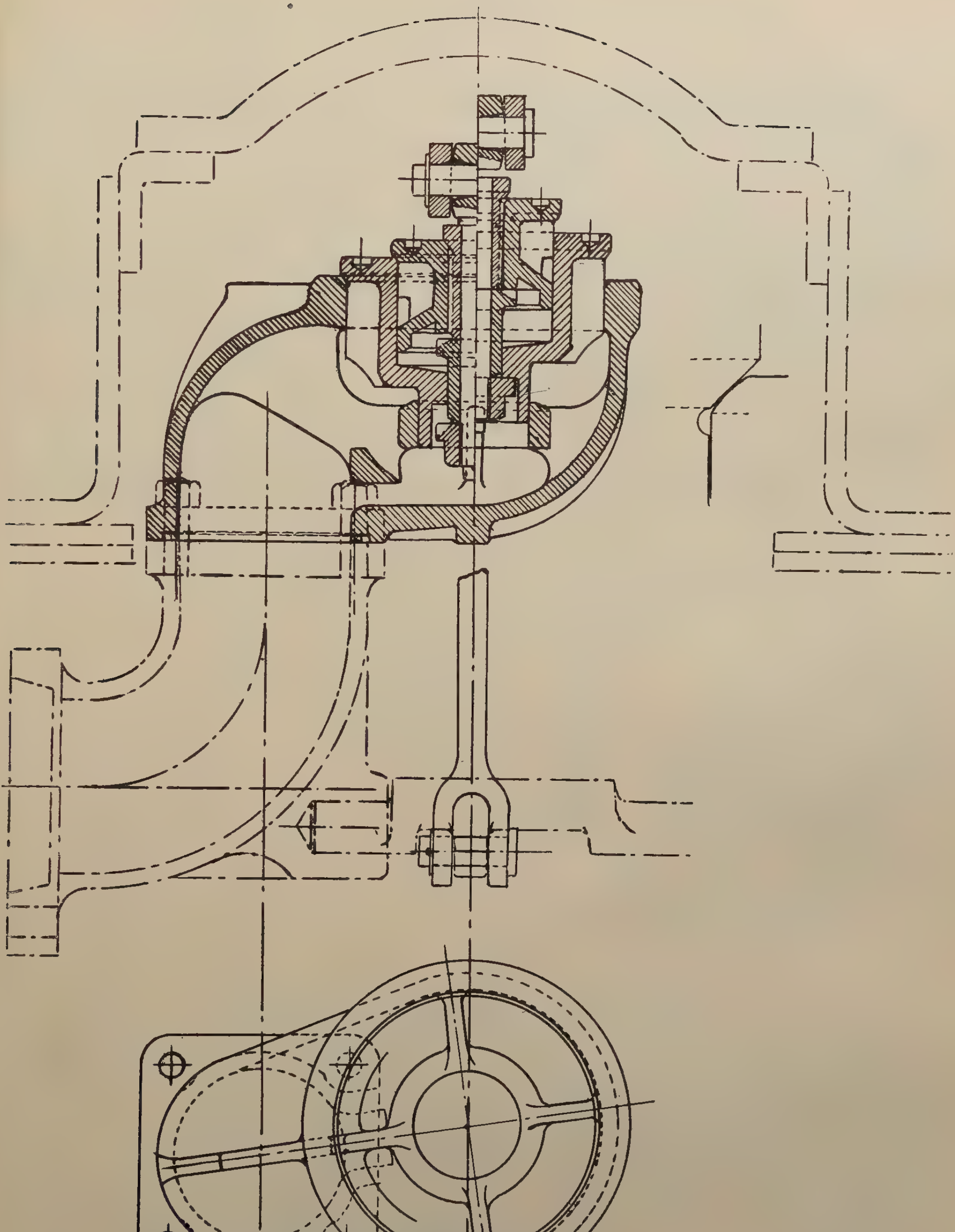


Fig. 16. — « Joco » type regulator as used on the London & North Eastern Railway.

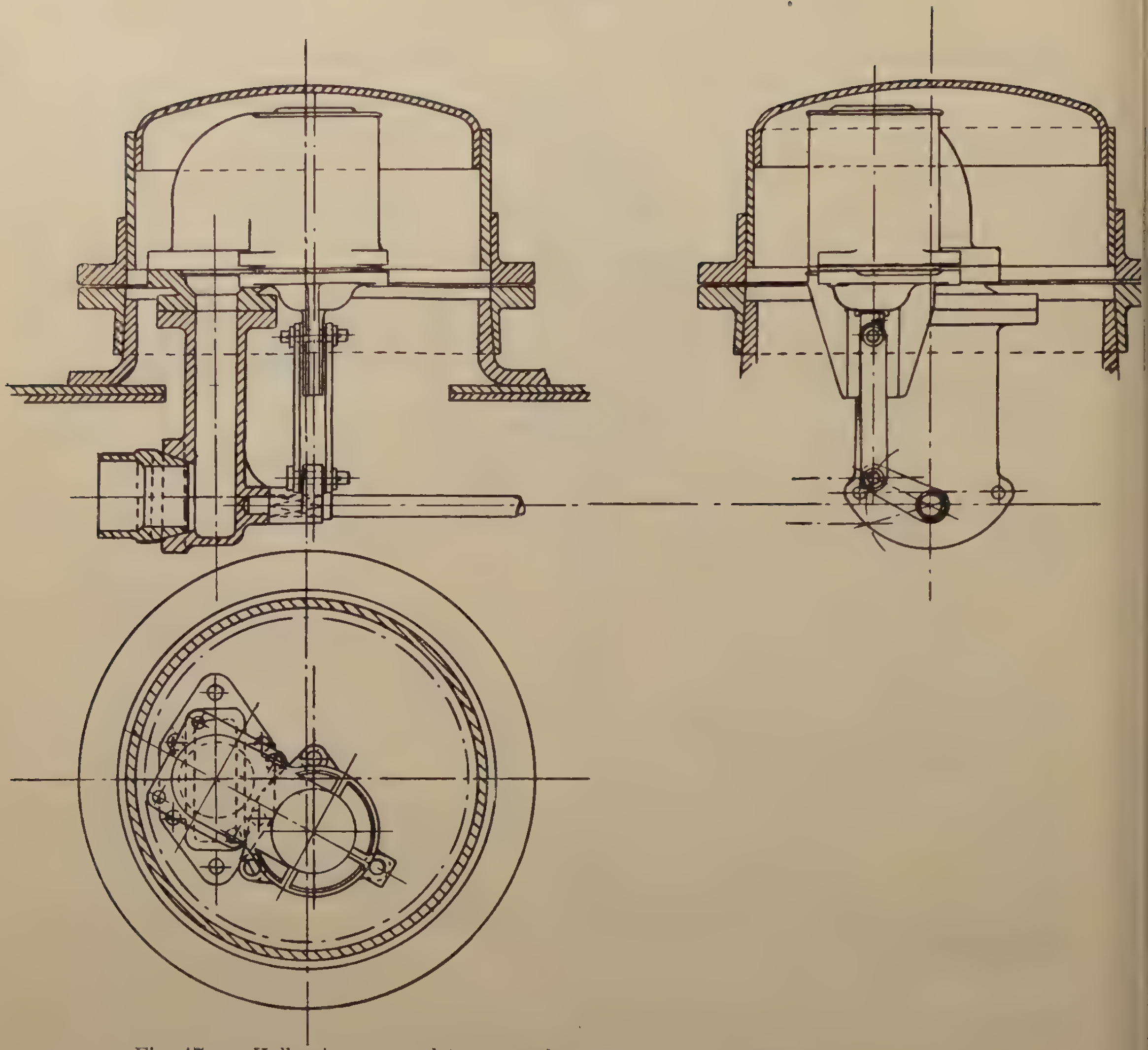


Fig. 17. — Hulburd servo-regulator as used on the Madras and Southern Mahratta Railway.

water from the steam to avoid the losses through the evaporation of this water and the cost of renewing the bends.

### F. — Soot blowers.

*Give any particulars of soot blowers in use, stating :*

a) *Make.*

The railways replying report the use of the American Railway Appliance, Parry, Diamond, and Clyde Superior, soot blowers (see figs. 20, 21 and 22).

b) *Position fitted.*

Both back and side plate types are used.

c) *Effect on roof, side and tube plates of box, brick arches, and tubes.*

The blowers have little detrimental ef-

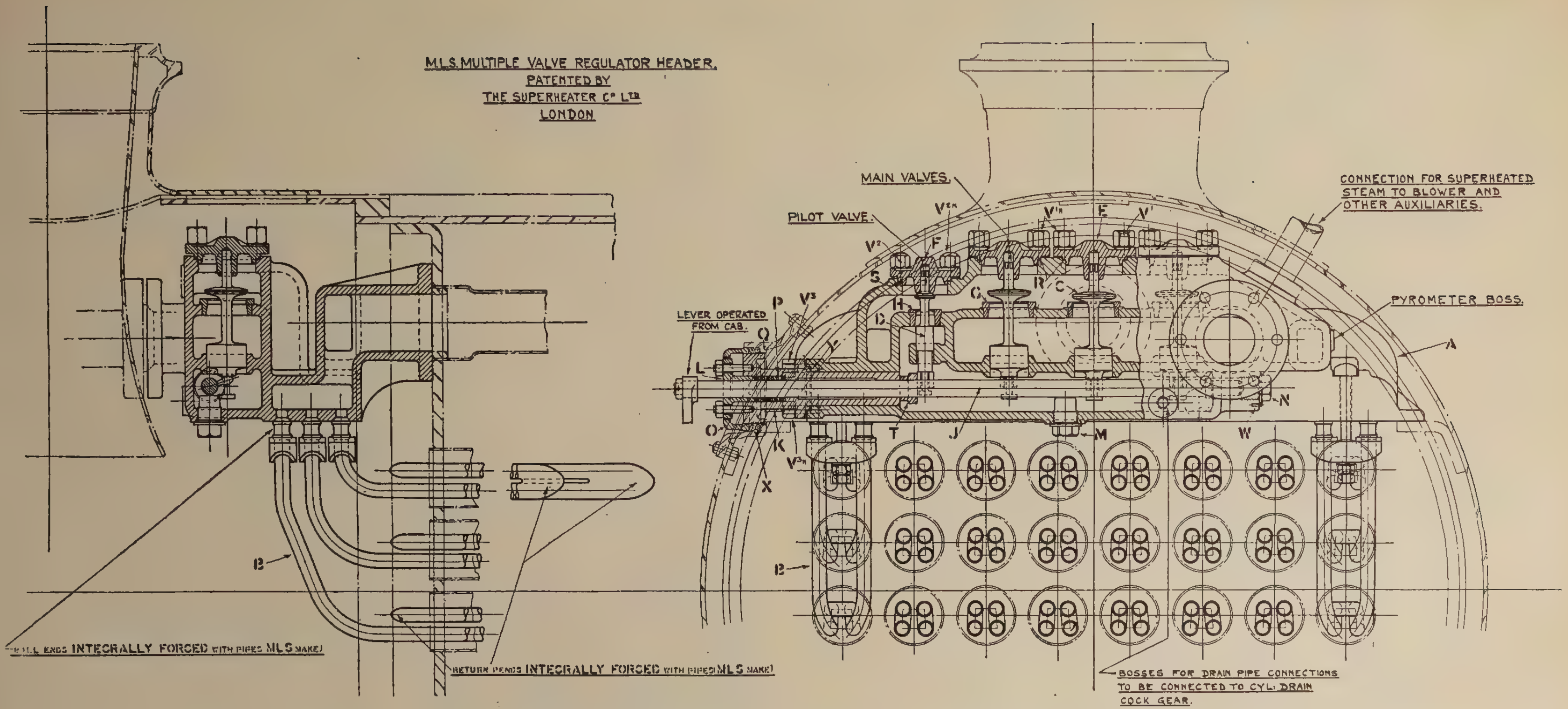

M.L.S. MULTIPLE VALVE REGULATOR HEADER.
PATENTED BY
THE SUPERHEATER Cº Ltd
LONDON
MAIN VALVES.
PILOT VALVE.
CONNECTION FOR SUPERHEATED STEAM TO BLOWER AND OTHER AUXILIARIES.
PYROMETER BOSS.
LEVER OPERATED FROM CAB.
BOSSES FOR DRAIN PIPE CONNECTIONS TO BE CONNECTED TO CYL: DRAIN COCK GEAR.
BALL ENDS INTEGRALLY FORGED WITH PIPES (M.L.S. MAKE)
RETURN BENDS INTEGRALLY FORGED WITH PIPES (M.L.S. MAKE)
V²ⁿ
V¹ⁿ
E
V¹
V²
F
S
C
R
C
H
D
P
V³
Q
L
O
K
X
V³ⁿ
T
J
M
W
N
A
B
B

Fig. 19. — Superheater Company's regulator incorporated in superheater header as fitted on the London & North Eastern Railway.

| Letter. | NAME OF PIECE. | Letter. | NAME OF PIECE. | Letter. | NAME OF PIECE. |
|---|---|---|---|---|---|
| A | Header with multiple valve regulator. | K | Regulator cam shaft stuffing box. | $V'$ | Studs for valve covers. |
| | Types AMV or AXV. | L | — stuffing box gland. | $V'_N$ | Nuts for valve covers. |
| B | Elements (ball joints). | M | — cam shaft bearing. | $V^2$ | Studs for pilot valve cover. |
| C | Regulator valve. | N | — cam shaft bushing. | $V^2_N$ | Nuts for pilot valve cover. |
| D | — pilot valve. | O | — casing gland. | $V^3$ | Studs for stuffing box. |
| E | — valve cover. | P | Stuffing box packing. | $V^3_N$ | Nuts for stuffing box. |
| F | — pilot valve cover. | Q | Casing (not supplied by Superhearter Co.). | W | Fixing screw. |
| G | — valve seat. | R | Joint ring for valve covers. | X | Packing. |
| H | — pilot valve seat. | S | Joint ring for pilot valve cover. | Y | Joint ring for stuffing box. |
| J | — cam shaft. | T | Cam shaft stop. | | |

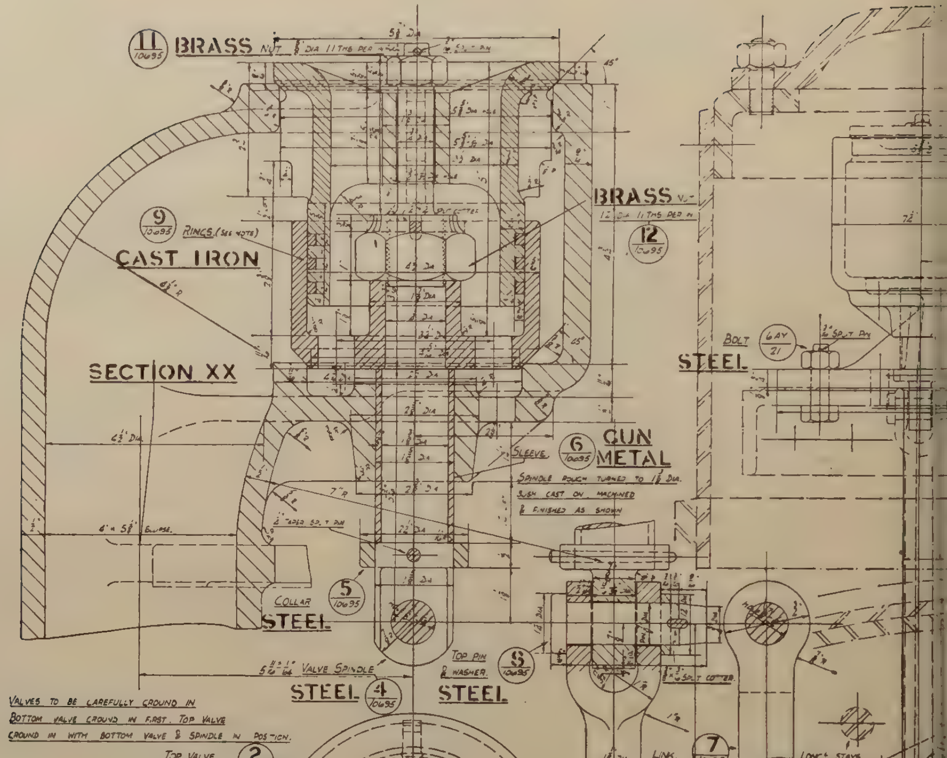
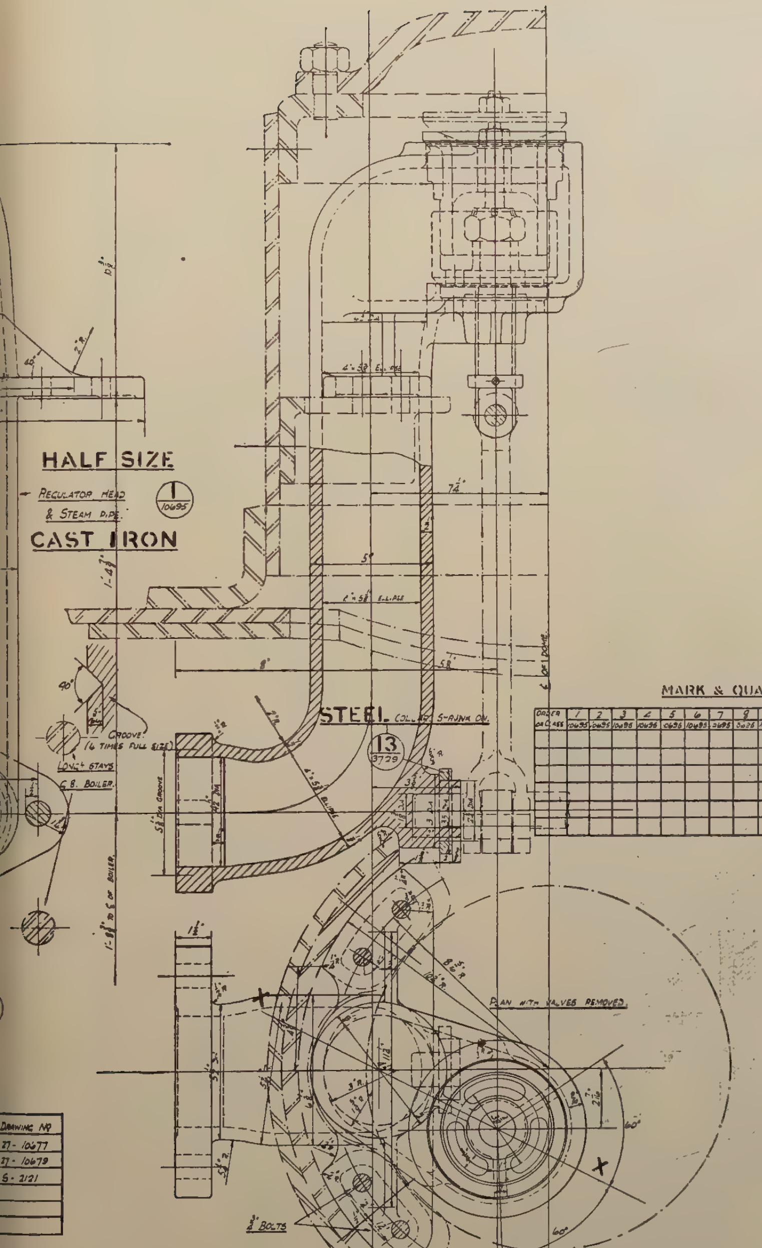


Fig. 18. — Balanced regulator of the London Mi



MARK & QUANTITIES REQUIRED

| Order or Class | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | WAY |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 10695 | 10695 | 10696 | 10696 | 10696 | 10695 | 10695 | 10696 | 10695 | 10695 | 10696 | 10695 | 3729 | 21 |  |
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| 27-10679 |
| S-2121 |
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|  |

VALVE. (OWEN'S PATENT).

PIPE.

Scottish Railway.

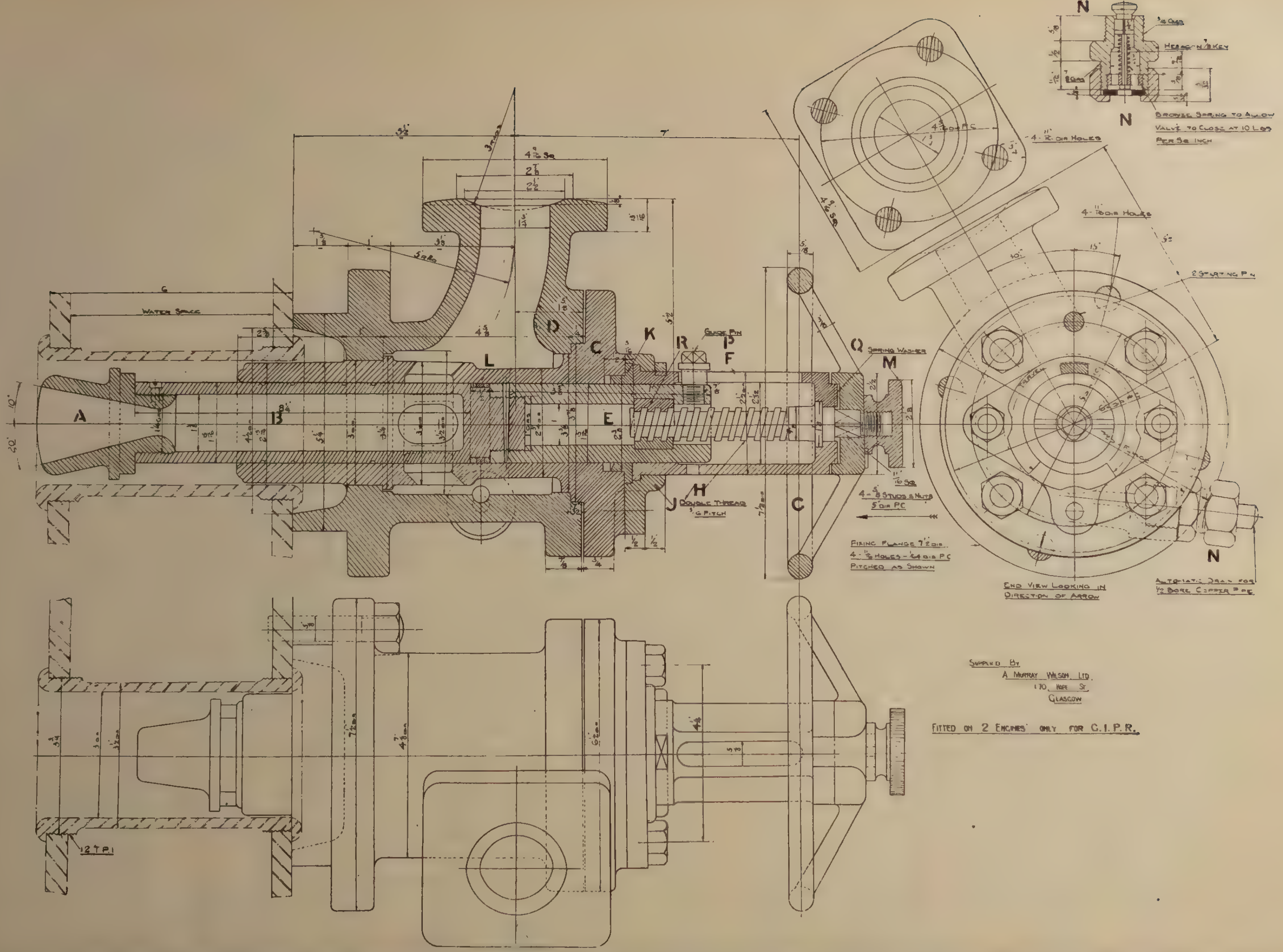


Fig. 20. — Clyde Superior tube cleaner on North Western Railway (India), Great Indian Peninsula Railway and East Indian Railway.

fect on the plates, but under certain conditions, excessive wear of the firebox tube plates is reported by the London Midland & Scottish. The Southern Railway of England reports that the effect of the blower is to stir up the accumulation of ash on the top of the brick arch and deposit this in the tubes, thus nullifying the good effects.

d) *Effect on fire.*

The reports generally indicate that there is a tendency to damp down the fire.

e) *Instructions as to when blower should be used, and time.*

Reports generally indicate that the blower should be used when the engine is working hard and at intervals of about 1 hour.

f) *Cost of repairs.*

Experience so far is limited, but the present evidence is that it will be very small.

g) *Whether any saving in labour of tube cleaning at sheds is effected.*

When properly used soot blowers save labour at the sheds, but there is not yet sufficient experience with them to say that they enable all tube sweeping to be discontinued.

No definite opinion can be expressed as to the value of soot blowers until further experience has been obtained in service.

## G. — Boosters.

*Give particulars and send drawings, together with pipe arrangements of boosters fitted :*

a) *To trailing carrying wheels.*

b) *To trailing bogies.*

| Letter. | NAME OF PART. | Material. | Rough weights. | Finished weights. | Letter. | NAME OF PART. | Material. | Rough weights. | Finished weights. |
|---|---|---|---|---|---|---|---|---|---|
| — | — | — | | | — | — | — | | |
| A | Nozzle | Heat resisting material. | 3 1/2 lb. | 3 lb. | J | Sleeve cover | Malleable. | 2 lb. 1 oz. | 1 1/4 lb. |
| B | Nozzle spindle | M. S. | 8 lb. 14 oz. | 3 lb. 11 oz. | K | Gland | G. M. | 10 1/2 oz. | 6 oz |
| C | Cover | C. I. | 20 lb. | 14 lb. 12 oz. | L | Ramsbottom rings | Steel. | — | 1 oz. |
| D | Chest | C. I. | 41 lb. | 32 lb. 5 oz. | M | Locking screw | M. S. | 16 oz. | 8 oz. |
| E | Outer spindle | M. S. | 4 lb. 10 oz. | 2 lb. 13 oz. | N | Automatic drain | G. M. | 17 oz. | 12 oz. |
| F | Sleeve | Malleable | 4 lb. 3 oz. | 2 lb. 5 oz. | P | Guide pin | M. S. | 3 oz. | 1 1/2 oz. |
| G | Hand wheel | — | 6 lb. 2 oz. | 4 lb. 13 oz. | Q | Spring washer | Steel. | — | 1 oz. |
| H | Screw | M. S. | 1 lb. 8 oz. | 13 oz. | R | Screw nut | G. M. | 14 oz. | 8 oz. |

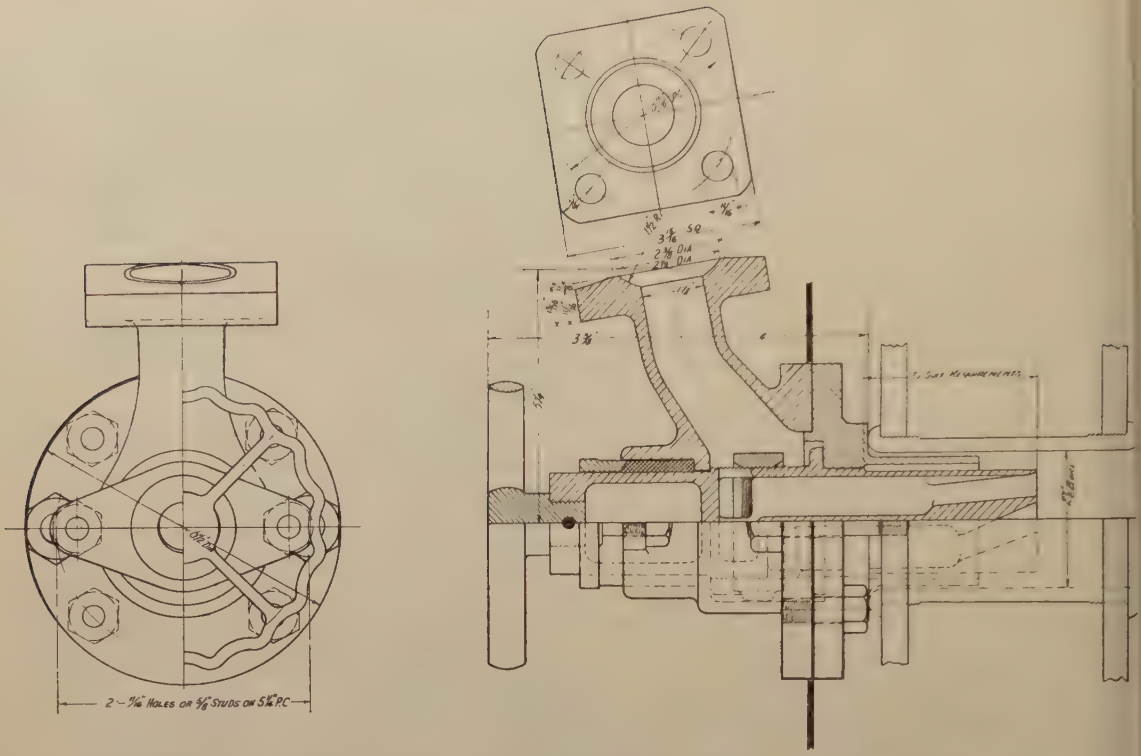


Fig. 21. — » Diamond » tube cleaner as used on the London & North Eastern Railway.

c) *To tender bogies and state number of engines, and of what types fitted.*

*To what extent has the booster :*

a) *Increased to speed ?*

b) *Increased the load of trains worked by booster fitted engines ?*

*Give particulars of any particular difficulties found in operation and maintenance and of steps taken to overcome them.*

*What effect has the booster had on the cost of maintenance and on the fuel consumption ?*

*Give particulars of any recent improvements in booster design, such as limited cut off, use of superheated steam, poppet valves, gear operation, suspension.*

The only railways reporting the use of boosters are the Canadian National who have 61 on the trailing truck and six on tender trucks, and the London & North Eastern who have fitted them on the trailing carrying wheels of one 4-4-2 passenger engine and two 2-8-2 mineral engines.

The Canadian National Railways have not replied to the detail questions.

The pipe arrangement of the booster as fitted to the London & North Eastern 4-4-2 engine is shown in figure 23, the arrangement being a development of the original American device, by substituting steam control for air control. The booster in question has also been altered so that it can be used not only for starting but also be engaged at low speeds up to

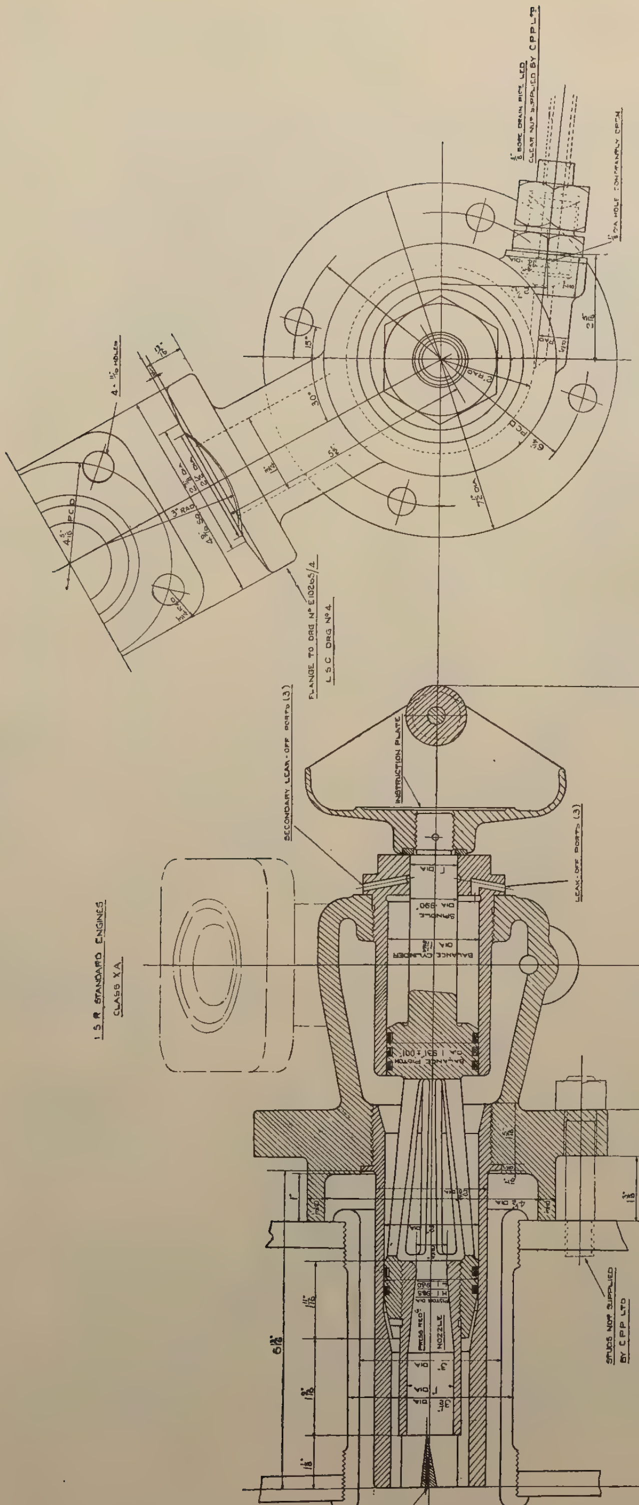


Fig. 22. — Arrangement of Parry's soot blower on the Great Indian Peninsula Railway.

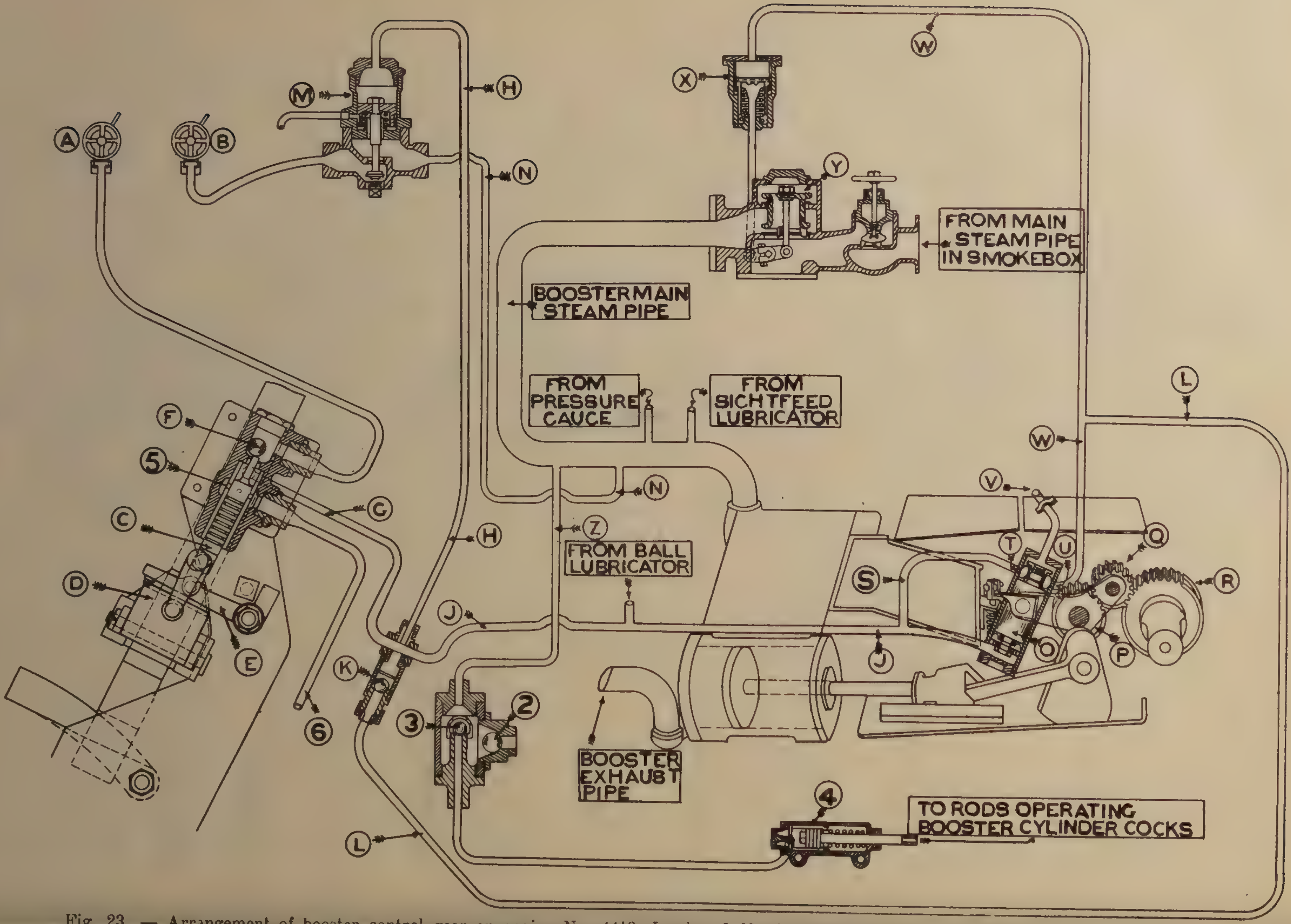


Fig. 23. — Arrangement of booster control gear on engine No. 4419, London & North Eastern Railway, as modified for steam operation.

28 miles per hour and run up to 35 miles per hour. The modified booster is shown in figure 23.

The effect of the booster on the 4-4-2 engine has been to increase its tractive effort from 17 340 to 25 840 and to enable it to work trains over severe gradients for which otherwise 4-6-0 engines would be needed. It also enables the engine to maintain its booked speed under abnormally bad conditions.

No report has been received as to the use of limited cut-off, superheated steam, or poppet valves on boosters.

### H. — Use of special alloy steels.

*Give particulars of alloy steel used in :*

a) *Motion, to lighten moving parts.*

b) *Frame, boiler, etc., to lighten dead weight of engine.*

c) *Springs. Attach specification, analysis, and describe method of heat treatment.*

Six railways report the use of special alloy steel :

*a*) For pistons, connecting rods and coupling rods.

*b*) No replies were received.

*c*) No replies were received.

Vibrac steel is used on the London Midland & Scottish and Southern Railways, nickel chrome on the London & North Eastern, and carbon vanadium on the South Manchuria and Chosen Railways.

The analysis and mechanical tests for Vibrac steel are as follows :

| | |
|---|---|
| Carbon . . . . . . . . . . | 0.32 % |
| Manganese . . . . . . . . | 6 % |
| Nickel. . . . . . . . . . . | 2.5 % |
| Chromium . . . . . . . . | 0.5 % |
| Molybdenum . . . . . . . | 0.6 % |

The booster consists of a two-cylinder engine running in full forward gear. A spur wheel P on its crank shaft is in mesh with an idle wheel Q carried on one end of a rocking lever; the other end of this is attached to a piston O held in the downward position by springs. When the piston is forced up, the rocking lever engages the idle wheel Q with a spur wheel R on the engine rear axle and also admits steam to the booster. The booster can only be operated when the main regulator valve is open and the reversing lever in forward gear in any position between full gear and 50 per cent cut off. It is put into action by means of the cam D on the reversing lever. On lifting the cam handle, lever E fulcrumed at its front end raises the valve spindle C, forcing the ball F off its seat. The top chamber containing this valve is in direct communication with the boiler through valve A. Steam is then free to flow into pipe G and thence to pipes H and J, ball valve K sealing pipe L. Steam flows through pipe H to preliminary throttle valve M. forcing down the piston against the spiral spring and opening mitre valve at lower end of stem. Boiler steam from valve B can then flow into pipe N to the booster steam pipe, warming up the cylinders and turning the engine round slowly before the gear wheels engage. Meanwhile steam flowing along pipe J has forced up piston O causing the rocking lever to engage wheels Q and R. Steam in branch pipe S is unable to pass port T till the gears have meshed and allowed the piston to complete its stroke, and no pressure can build up in pipe W as port U is in communication with exhaust pipe V till the gears have started to engage. As soon as they are fully engaged, port U is shut off from exhaust and put in communication with port T. Steam then flows into pipe W leading to throttle operating cylinder X. The piston in this is forced down against the action of the spiral spring, thus opening double beat valve Y in the booster main steam pipe by means of the lever shown. Superheated steam then flows to the booster; when tme main regulator valve is open. Water drains from the steam pipe down pipe Z and escapes via ball valve 2. When steam pressure builds up this valve is blown on to its seat. The booster cylinder cocks are automatically operated ball valves governed by ball 3. Leakage grooves on the seat of this allow pressure to slowly build up in cylinder 4 compressing the spring shown and allowing the ball valves to close after the booster has been in operation about half a minute.

The booster is put out of action by knocking down the handle on cam D, or pulling the reversing lever up further than 50 per cent, this frees lever E and valve spindle C is forced down by the pressure of steam on it. Ball valve F then seats itself, cutting off all steam from the valve body. The further downward travel of the valve spindle C uncovers ports 5, placing them into communication with exhaust pipe 6 allowing pressure to be released from H and J via pipe G. The spring in preliminary throttle valve M closes the valve and shuts off the steam supply from valve B to pipe N. At the same time piston O is returned to the downward position by its release springs, thus disengaging the gear wheels Q and R and putting port U in communication with exhaust pipe V allowing pressure to escape from pipe. W. The drop in pressure in pipes H and J has already allowed ball valve K to open the by-pass pipe L thus accelerating the release of pressure in pipe W and throttle operating cylinder X, the release spring in this can now move up the piston and close double beat valve Y. As soon as pressure falls in the booster steam pipe, ball valve 3 is lifted off its seat by the pressure in cylinder 4, thus quickly exhausting the cylinder, the spring in it forces back the piston, and rods connected to this open the cylinder cocks by forcing the balls off their seats.

Tensile 50/60 tons;

20 % elongation on 3 inches.

The analysis and mechanical tests for chrome nickel are as follows :

| | |
|---|---|
| Carbon | 0.33 % |
| Silicon | 0.21 % |
| Manganese | 0.60 % |
| Sulphur | 0.032 % |
| Phosphorus | 0.039 % |
| Nickel | 3.42 % |
| Chromium | 0.60 % |

Tensile 40/45 tons;

Ultimate breaking stress not less than 50 tons;

Elongation 18 % minimum.

Yield point not less than 40 tons.

*In typical instances, such as connecting and coupling rods, piston heads and pistons, give particulars of weight saved.*

The savings in weight resulting from the use of such steel may be taken as not less than 30 %.

The results obtained with these alloy steels have been entirely satisfactory, and their use is desirable in all cases owing to the reduction in the weight of the moving parts.

The heat treatment requiring extreme care, such materials when damaged should only be dealt with at the main repair shops.

### I. — Use of special light alloys, such as aluminium alloys.

*Give particulars of any such special light alloys used in :*

a) *Motion parts.*

b) *On locomotives generally, attaching specifications.*

*Are die castings being used to any extent, and if so, for what purposes ?*

*Give particulars of costs of such materials and of savings in weight, cost of fitting, etc.*

*Give any particulars of the life of parts made from such alloys.*

*Has any trouble occurred through such material deteriorating in service ?*

No railway reports the use of light alloys such as aluminium for any locomotive parts.

## SUMMARY.

As a result of an examination of the replies received to the questionnaire sent out to the various Railway Companies, the following general conclusions are arrived at :

*a*) The increase in boiler pressure on certain classes of engines gives some economy in fuel and water consumption, whilst at the same time there is an increase in cost of maintenance of fireboxes. Higher pressures have resulted in more powerful locomotives being built within the loading gauge limit.

*b*) That 750° F. appears to be the highest temperature that can be generally regarded as satisfactory in locomotive work.

*c*) Feed water heaters, of the exhaust injector type are most widely used. Feed water heaters of the open type are becoming more widely used owing to their increase in efficiency.

*d*) Air preheating arrangements have

not been applied to locomotives of the current Stephenson type.

*e*) The introduction of poppet valves as a means for steam distribution is increasing. There is a marked tendency with piston valves to give more lap on valves with longer valve travel.

*f*) There is no standard design of smokebox lay-out. Efforts have been made with blast pipe arrangements to improve the blast and to reduce back pressure. The improvement in engine efficiency has resulted in the smoke not being lifted clear of the boiler. Several experiments are being made to remedy this, and some redesign of the front end may be necessary to overcome this difficulty.

*g*) Replies show that compounding is not being extended except on a few railways using Mallet engines.

*h*) The usual arrangements of ash-pan and dampers, brick-arch and firehole door meet all requirements.

*i*) The use of thermic syphons can only be justified under special circumstances.

*j*) There is a marked tendency towards the adoption of regulators of the double beat balanced type.

*k*) Steam dryers have met with little success.

*l*) Soot blowers have been widely introduced and labour in tube cleaning at locomotive depots has been reduced.

*m*) Boosters have been introduced in two countries only, and have given satisfactory results.

*n*) The use of special alloy steels for coupling rods and motion parts is becoming more general, and has effected a reduction in weight of reciprocating and revolving parts. The results obtained are entirely satisfactory and have contributed to improved engine balancing.

*o*) No railways report the use of light alloys.

### Acknowledgment.

The reporter desires to acknowledge the information so readily supplied by the various Railway Companies and Railway Contractors.

Summary of replies t

| QUESTION. | China. | |
|---|---|---|
| | *South Manchuria Railway.* | *Great Western Railway.* |
| Chapter I. — **Increased boiler pressure.** | | |
| 1. *Recognised standard boiler pressure on passenger and goods locomotives built since 1922.* | 200 lb. per sq. inch, passenger.<br>190 lb. per sq. inch, goods locomotives. | 200 to 250 lb. per sq. inch. |
| 2. *Particulars of any boiler having increased pressure up to 284 lb. per square inch and leading dimensions of the locomotives concerned; state if locomotives in question were existing engines converted. If so, give particulars of engines before and after conversion and number converted.* | ... | Nil. |
| 3. *Results of tests of such boilers, especially as regards :* | | |
| a) *Fuel and water economy* . . . . . . | ... | ... |
| b) *Superheat obtained* . . . . . . . . . | ... | ... |
| 4. *Effect of increased pressure on :* | | |
| a) *Repairs to boilers* . . . . . . . . . . | ... | Nothing to report. |
| b) *Repairs to cylinders, valves, pistons and packings.* | ... | ... |
| c) *Time engines are out of traffic* . . . . | ... | ... |
| d) *Cost of repairs* . . . . . . . . . . . | ... | ... |
| e) *Cost of lubrication* . . . . . . . . . | ... | ... |
| f) *Periodical examination of :* | | |
| I. *Boiler* . . . . . . . . . . . . . | ... | ... |
| II. *Valves and pistons* . . . . . . . . | ... | ... |
| g) *Details of any failures of parts, etc., occurring in service due to the increase in pressure.* | ... | ... |
| 5. *General remarks as to results of raising boiler pressure above recognised standard.* | ... | ... |

led list of questions.

## eat Britain and North of Ireland. — Principal Companies.

| London Midland & Scottish Railway. | London & North Eastern Railway. | Southern Railway. |
|---|---|---|
| class of standard passenger en- nes have working pressure 250 lb., her standard passenger and ight engines have pressure vary- g from 160 to 200. | 180 lb. per sq. inch. | 220 lb. per square inch. |
| « Royal Scot » class have a work- pressure of 250 lb. and were ilt as such. | Fifteen 4-6-2 class passenger locomotives have had their boiler pressure raised from 180 lb. to 220 lb. per square inch. | 220 lb. has been used in the largest 4-6-0 type engines. These are of new construction. |
| have no comparative figures for gines with high and low boiler essure used under exactly similar nditions. | *a*) 220 lb. boiler. Coal per 100 ton-miles : 6.4 lb. Water per 100 ton-miles : 50 lb.<br>180 lb. boiler. Coal per 100 ton-miles : 7.2 lb. Water per 100 ton-miles : 58 lb. | *a*) No special test has been made to ascertain the economy arising with increased pressure only. Compared with rather smaller 200-lb. boilers it is found that the evaporation of water per pound of coal is appreciably greater. |
| ... | *b*) Superheat obtained 7 % higher with 220-lb. boiler. | *b*) The steam temperature obtained is about 600° to 620° F. |
| comparative figures yet avail- le. | *a*) Increase in repairs to fireboxes of boilers having 220-lb. pressure. | From the short time the 220-lb. boilers have been in service, it is not possible to give any definite information : up to the present no appreciable increase in cost of repairs, etc., has been found. |
| Do. | ... | |
| Do. | ... | |
| Do. | ... | |
| delivery from mechanical lubri- tor is not increased on account higher pressure. | ... | |
| dard periodical examination pe- ods apply to these engines. | ... | ... |
| failures have occurred debitable the higher pressure. | ... | ... |
| « Royal Scot » class has given ry economical results which may attributed in part to the high essure and in part to other fea- res such as valve gear design, iler proportions and exhaust in- tors. | Whereas there is some economy in fuel and water consumption, there is an increase in cost of boiler maintenance. | One result of raising the boiler pressure is that greater power can be obtained within the limits of the loading gauge. |

| QUESTION. | **Great Britain & Northern Ireland** (*continued*). | | |
|---|---|---|---|
| | *Great Northern Railway, Ireland.* | *London Midland & Scottish. (Northern Counties Committee)* | *Rhodesian Railways.* |
| Chapter I. — **Increased boiler pressure.** | | | |
| 1. *Recognised standard boiler pressure on passenger and goods locomotives built since 1922.* | 175 lb. per square inch; 200 lb. for main line express locomotives. | 175 lb. | 180 to 190 lb. sq. inch. |
| 2. *Particulars of any boiler having increased pressure up to 284 lb. per sq. inch and leading dimensions of the locomotives concerned. State if locomotives were existing engines converted, and if so, give particulars before and after conversion and number converted.* | The pressure on 8 main line engines 18 months ago raised to 200 lb. Existing engines and boilers fitted with new copper boxes. Type 4-4-0 — 19" × 26" cylinders — 6'-7" diameter wheels. Tractive effort 20 198 lb.; weight 52 tons, 10 cwt. | No trials of boilers having increased pressure have been made. | No increase on standard boil pressure has be tried. |
| 3. *Results of tests of such boilers especially as regards :* | | | |
| a) *Fuel and water economy* . . . . . . . | ... | ... | ... |
| b) *Superheat obtained* . . . . . . . . | No noticeable difference. | ... | ... |
| 4. *Effect of increased pressure on :* | | | |
| a) *Repairs to boilers* . . . . . . . . . | No noticeable difference after 80 000 miles has been noticed in any of these items. | ... | ... |
| b) *Repairs to cylinders, valves, pistons and packings.* | | | |
| c) *Time engines are out of traffic* . . . . | | | |
| d) *Cost of repairs* . . . . . . . . . | No noticeable difference. | ... | ... |
| e) *Cost of lubrication* . . . . . . . . | Do. | ... | ... |
| f) *Periodical examination of :* | | | |
| I. *Boiler* . . . . . . . . . . . . | Do. | ... | ... |
| II. *Valves and pistons* . . . . . . . | Do. | ... | ... |
| g) *Details of any failures of parts, etc., occurring in service due to the increase in pressure.* | Increased trouble with hot big end bearings has ensued but better quality oil has reduced the trouble. | ... | ... |
| 5. *General remarks as to results of raising boiler pressure above recognised standard.* | Increased pressure has resulted in heavier loads being taken without loss of time. | ... | ... |

| Africa. | | Australasia. | |
|---|---|---|---|
| *uth African Railways.* | *Sudan Government Railways.* | *New South Wales Government Railways.* | *New Zealand Government Railways.* |
| e existing standard boiler pressure ranges from 180 to 215 lb. | 180 lb. | 160 lb. — Goods.<br>180 — Passenger. | The highest boiler pressure owned by the Railway Department is 230 lb. on boilers of the X class compounds. |
| ere are no boilers in service having a higher pressure than 215 lb. | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | Canada. | India. | | | | | |
|---|---|---|---|---|---|---|---|
| | *Canadian National Railways.* | *Ceylon Government Railway.* | *Eastern Bengal Railway.* | *East Indian Railway.* | *Great Indian Peninsula Railway.* | *Madras and Southern Mahratta Railway.* | *South Indian Railway.* |
| Chapter I *(continued).* | | | | | | | |
| 1. *Recognised standard boiler pressure on passenger and goods locomotives built since 1922.* | Passenger 250 lb.<br>Freight 210 lb. | . ... | 180 lb. | 180 lb. | 180 lb. | 180 lb. | 180 lb. |
| 2. *Particulars of any experiments, etc.* | No remarks. | No remarks. | No remarks. | No remarks. | No remarks. | No remarks. | No remarks. |
| 3. *Results of such tests* . . . . | Do. | Do. | Do. | Do. | Do. | Do. | Do. |
| 4. *Effect of increased pressure on., etc.* | Do. | Do. | Do. | Do. | Do. | Do. | Do. |
| 5. *General remarks, etc.* . . . . | Do. | Do. | Do. | Do. | Do. | Do. | Do. |

| QUESTION. | Malaysia. | Japan. | |
|---|---|---|---|
| | *Federated Malay States Railways.* | *Japanese Government Railways.* | *Government General of Chosen.* |
| Chapter I *(continued)*. | | | |
| 1. *Recognised standard boiler pressure on passenger and goods locomotives built since 1922.* | 180 lb. | 200 lb. | ... |
| 2. *Particulars of any boiler having increased pressure up to 284 lb., etc.* | It is hoped shortly to experiment with higher boiler pressures. | To increase the boiler pressure is under investigation and experiments on higher pressures than 200 lb. per sq. inch have not yet been carried out. | ... |
| 3. *Results of tests of such boilers, etc.* | ... | .. | ... |
| 4. *Effect of increased pressure on., etc.* | ... | .. | ... |
| 5. *General remarks as to results of raising boiler pressure above recognised standard.* | ... | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midla & Scottish Rail |
| Chapter II. — **Superheating.** | | | |
| 1. *Give particulars of any experimental superheaters used, giving temperatures exceeding 700° F.* | ... | No experimental superheaters have been fitted. | We have not fitte experimental supe ers giving temper exceeding 700° F. |
| a) *Results obtained, temperatures and amount of coal saved.* | ... | ... | ... |
| b) *What modifications had to be made to :* | | | |
| 1. *Valves, pistons and packings.* | ... | ... | ... |
| 2. *Lubricator and lubricants.* | ... | ... | ... |
| 3. *Exhaust or blast pipe chimney or smokebox.* | ... | ... | ... |
| 4. *Header.* | ... | ... | ... |
| 5. *Regulator.* | ... | ... | ... |
| c) *Effect on maintenance :* | | | |
| 1. *Repairs.* | ... | ... | ... |
| 2. *Cost of repairs to superheater.* | ... | ... | ... |
| 3. *Details of any part that has given trouble and steps taken to remedy it.* | ... | ... | ... |
| 2. a) *What is the maximum temperature considered practicable in locomotive work?* | ... | ... | We have no exper with temperatures a 650° F. except on fired locomotives. ble experienced. |
| b) *What type and make of pyrometer is fitted, and is it found necessary to fit all engines with pyrometers?* | Elesco steam pyrometer. Provision is made so that pyrometers are readily fitted to all superheated engines whenever needed. | Pyrometers are not fitted on Great Western Railway engines. | We only fit pyrom for special tests. |
| c) *What type of cylinder relief valves, snifting valves or bye-passes are used?* | Mellin bye pass valve.<br>Sneedy bye-pass valve. | Spring loaded relief valves. Gravity air valves. Bye-passes are not used. | ... |

## Great Britain and North of Ireland.

| don & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
|---|---|---|---|
| xperiments have been de. | No superheaters in use giving over 700° F. | Any superheater apparatus tried, has not given temperatures exceeding 700° F. | The only experimental superheater is of Cruse's Patent made by Bolton Superheater Company. It does not purport to give high temperatures, and is so far unsuccessful. |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| 700°—750° F. | Cannot say from experience. | 800° F. Return tube in use on this railway has not given more than 650° F. | ... |
| s not been found ne- sary to fit all engines h pyrometers. | Not fitted for regular use. | Three Mercury types tried. Cambridge Instrument Mercury, steel type most successful. No type capable of standing rough usage in running shed. All headers fitted with a branch and temperatures taken from time to time. | ... |
| g loaded cylinder re- valve. Anti-va- m valve. | Air relief valves on header casting. Use of bye-passes discontinued. | Relief valve. Spring loaded bevel face valve. Snifting valve. Spring loaded flat face valve with inside and outside spindle guides. Bye-pass not used. | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Govern<br>Railways. |
| Chapter II *(continued).* | | | |
| 1. *Give particulars of any experimental superheaters used, giving temperatures exceeding 700° F.* | No superheaters have been introduced giving temperatures above 680° F. | A higher superheat than 700° F. has not been used. | ... |
| a) *Results obtained, temperatures and amount of coal saved.* | ... | ... | ... |
| b) *What modifications had to be made to :* | | | |
| 1. *Valves, pistons and packings.* | ... | ... | ... |
| 2. *Lubricator and lubricants.* | ... | ... | ... |
| 3. *Exhaust or blast pipe, chimney or smokebox.* | ... | ... | ... |
| 4. *Header.* | ... | ... | ... |
| 5. *Regulator.* | ... | ... | ... |
| c) *Effect on maintenance:* | | | |
| 1. *Repairs.* | ... | ... | ... |
| 2. *Cost of repairs to superheater.* | ... | ... | ... |
| 3. *Details of any part that has given trouble and steps taken to remedy it.* | ... | ... | ... |
| 2. a) *What is the maximum temperature considered practicable in locomotive work?* | Have no practical experience of temperatures over 680° F. | ... | ... |
| b) *What type and make of pyrometer is fitted, and is it found necessary to fit all engines with pyrometers?* | At present Foster pyrometer is fitted to a few locomotives. | ... | Pyrometers not no |
| c) *What type of cylinder relief valves, snifting valves or bye-passes are used?* | Relief valves spring-loaded to blow off at boiler pressure. Snifting valves of Gresley air valve system. Byepass valve of Hendrie's system. | ... | Cylinder relief<br>Release rings f<br>piston valve.<br>compression re<br>ves set to blov<br>165 lb. workin<br>ure. Snifting v<br>ted to header.<br>valve fitted, to<br>valve steam<br>York Patent<br>valve fitted, but afterwards remove<br>pass valve, Fowler & Sanderson. |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| None in service. | No superheaters giving temperatures in excess of 700° F. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| 650° F. | 650°—700° F. | 750—800° F. | ... |
| Pyrometers not generally fitted, used for tests of new engines. | One pyrometer by Negretti & Zambra tried. Not thought necessary to extend to all locomotives. | Electric type, Bristol and Tycos. Not necessary to fit all engines. | ... |
| Cylinder release V seat type valve. 20 lb. in excess of boiler pressure.<br>Snifting valves of pneumatic type.<br>Bye-pass valves not fitted. | Spring loaded relief valves combined with cylinder cocks. Snifting valves fitted just above steam chest. A small amount of saturated steam is introduced into each steam pipe near snifting valve. This is controlled by screw down stop valve in cab. Bye-pass valves not used. | Poppet valves (World). | ... |

| QUESTION. | India (continued). | | |
|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Penin Railway. |
| Chapter II (continued).<br>1. *Give particulars of any experimental superheaters used, giving temperatures exceeding 700° F.* | None in use. | None in use. | None in use. |
| a) *Results obtained, temperatures and amount of coal saved.* | ... | ... | ... |
| b) *What modifications had to be made to (1, 2, 3, 4, 5).* | ... | ... | ... |
| c) *Effect on maintenance (1, 2, 3).* | ... | ... | ... |
| 2. a) *What is the maximum temperature considered practicable in locomotive work?* | 600° to 650° F. | ... | 650° F. standard. |
| b) *What type and make of pyrometer is fitted, and is it found necessary to fit all engines with pyrometers?* | Not necessary to fit all engines. | ... | Steinl's electrical py eter; Schaffer and denberg, Superhe Corp.; Cambridge dex thermometer. not when fitted wit L. S. type superhea |
| c) *What type of cylinder relief valves, snifting valves or bye-passes are used?* | Hendrie bye-pass valve and an anti-vacuum valve is fitted on header. | ... | Relief valve (fig. 5 Hendrie's bye-pass v (fig. 6). |

| QUESTION. | |
|---|---|
| Chapter III. — **Feed water heating.** | |
| A. — *Heaters in which water is heated by combustion gases.* | |
| 1. *Number of engines fitted.* | No Railways report any feed water heaters of this description in use. |
| 2. *Name of Makers of feed water heater.* | |
| 3. *Results of tests giving coal and water consumption. Average temperature of feed water when leaving heater.* | |
| 4. *Influence of heater on partial softening of feed water when leaving the heater.* | |

| | | Malaysia. | Japan. | |
|---|---|---|---|---|
| dras & Southern ahratta Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| None in use. | No experiments. | None in use. | No experiments. | No experiments. |
| .. | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |
| use 650—700° F. ave no experience higher tempera- re. | ... | 650° F. | 350 C. taking into consideration troubles to packing (and lubrication in cylinder) due to high temperature. | ... |
| ometers not fitted standard. | ... | Pyrometers not standard. Portable apparatus by Foster Instrument Co., for occasional testing. | Mercury type, tension type, and electric. None give satisfaction. Not found necessary to fit. | |
| drie's bye-pass val e. Snifting valves ot fitted. Rely on e-pass and steam ifting valve. (See gs. 5 and 6.) | ... | K. class have spring loaded relief valve on cylinder. Drifting valve on header. S. class have spring loaded relief valve and bye-pass and vacuum valve on cylinder. | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria. | Great Western Railway. | London Midland & Scottish Railwa |
| Chapter III *(continued)*. | | | |
| **B. Exhaust steam injectors.** | | | |
| 1. *Number of engines fitted* . . | 11 | 1100 | In addition to som older type engines, recently built loc tives fitted. |
| 2. *Name of Makers of feed water heaters.* | Davies & Metcalfe.<br>Superheater Co. | Davies & Metcalfe. | Davies & Metcalfe |
| 3. *Results of tests* . . . . . | ... | ... | Coal economy :<br>Freight . . . . 8<br>Passenger . . 9.<br>No data for tempera of feed water ente boiler. |
| 4. *Influence of heater on partial softening of water.* | ... | ... | .. |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesia Railways. | South African Railways. | Sudan Governmen Railways. |
| Chapter III *(continued)*. | | | |
| **B type.** | | | |
| 1. *Number of engines fitted* . . | ... | 7 | ... |
| 2. *Name of Makers of feed water heaters.* | ... | Davies & Metcalfe. | ... |
| 3. *Results of tests* . . . . . | ... | Injectors removed and replaced by ordinary injectors owing to greater convenience of stocking spare parts. | ... |
| 4. *Influence of heater on partial softening of water.* | ... | ... | ... |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| London & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| 250 engines fitted with exhaust steam injectors. | 234 | No experiments | No experiments. |
| Davies & Metcalfe. | Davies & Metcalfe. | ... | ... |
| Coal economy: 7 to 8 %.<br>No data for temperature of feed water. | 2 1/2 to 5 % coal saving depending on service.<br>10 % water saving.<br>170° F to 190° F. | ... | ... |
| No difference compared with ordinary injector. | No difference compared with ordinary injector. | ... | ... |

| Australasia | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| 470 | 1 | ... | 168 |
| Davies & Metcalfe. | Davies & Metcalfe. | ... | Davies & Metcalfe. |
| Road tests show that when consistently operated by enginemen consumption of coal reduced by 4.5 % and water by 5.5 %. Temperature of water 155° F. | Exhaust injector tried but results did not justify its adoption. Further experiments to be made with latest pattern of exhaust injector. | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | India (*continued*). | | | | |
|---|---|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Peninsula Railway. | Madras & Southern Mahratta Railway. | South Indian Railway. |
| Chapter III *(continued).* | | | | | |
| B. — **Exhaust steam injectors.** | ... | ... | ... | B. — Nil. | B. — Nil. |
| C. — **Exhaust steam feed water heaters, feed water passing through tubes heated on outside by exhaust steam.** | ... | ... | ... | C. — Nil. | ... |
| D. — **Exhaust steam feed water heaters into which exhaust steam comes in direct contact with feed water.** | ... | ... | ... | ... | D. — Nil. |
| 1. *Number of engines fitted* . . | ... | ... | ... | 1 (D) in 1924. | 13 (C) 4-6-0 type. |
| 2. *Name of Makers of feed water heater.* | ... | ... | ... | Worthington Simpson. | Weir—feed pump. |
| 3. *Result of tests* . . . . . | ... | ... | ... | No pronounced results from its use. | The few engines fitted showed a saving of 2.5 lb. per train-mile owing to the water not being good. |
| 4. *Influence of heater on partial softening of water.* | ... | ... | ... | ... | Scale forms to a great extent in the tubes of these heaters, which must to a great extent impair the amount of the heat transferred from the exhaust steam. |
| 5. a) *What type of oil separator is used?*<br>b) *What amount of oil remains in the steam after passing through the separator?*<br>c) *Has this led to any ill effects?*<br>6. *Has trouble due to formation of scale in the tubes been experience with heaters of type C.* | ... | ... | ... | ... | Nil. |

| QUESTION. | Malaysia | Japan. | |
|---|---|---|---|
| | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| Chapter III *(continued).* | | | |
| B. — **Exhaust steam injectors.** | | | |
| 1. *Number of engines fitted* . . . . | None fitted. | None fitted. | 3 |
| 2. *Name of Makers of feed water heater.* | ... | ... | Davies & Metcalfe. |
| 3. *Results of tests.* . . . . . . . . | ... | ... | No substantial economy in coal or water consumption experienced, compared with engines of same type equipped with ordinary injectors. |
| 4. *Influence of heater on partial softening of water.* | ... | ... | No information available. |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland & Scottish Railwa |
| Chapter III *(continued).* | | | |
| C. — **Exhaust steam feed water heaters, feed water passing through tubes heated on outside by exhaust steam.** | | | |
| 1. *Number of engines fitted . .* | 1 — 4-6-2 type.<br>1 — 2-10-0 type. | Nil. | Nil. |
| 2. *Name of Makers of feed water heaters.* | Superheater Co. | ... | ... |
| 3. *Results of tests . . . . .* | *Coal :*<br>4.6 lb. per 100 ton-miles, C type only.<br>4.9 lb. per 100 ton-miles, B type.<br>*Water :*<br>33.2 lb. per 100 ton-miles, C type.<br>35 lb. per 100 ton-miles, B type.<br>Average temperature of feed water 89° C. | ... | ... |
| 4. *Influence of heater on partial softening of water.* | ... | ... | ... |
| 6. *Has trouble due to formation of scale in the tubes been experienced with the use of type C?* | ... | ... | . . |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| London & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| 0 – 2-8-0 type. Mineral locomotives fitted prior to 1922. Heaters unsatisfactory and have been removed. | Tubular feed water heaters have been tried in conjunction with pumps or hot water injectors but their use has been abandoned in favour of exhaust injectors. | ... | ... |
| Weir. | .. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | .. | ... |
| ... | Yes. | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Government Railwa |
| Chapter III *(continued).* | | | |
| **C type :** | | | |
| 1. *Number of engines fitted* . . | ... | .. | 24 — 2-8-2. |
| 2. *Name of Makers of feed water heaters.* | ... | ... | Weir feed water hea<br>and pump. |
| 3. *Results of tests* . . . . . | ... | ... | No results available |
| 4. *Influence of heater on partial softening of water.* | ... | ... | Very appreciable in b<br>water districts. |
| 6. *Has trouble due to formation of scale in the tubes been experienced with the use of type C?* | ... | ... | Yes — but preferably he<br>than in the boiler<br>easier got out. |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| ... | ... | 357 Elesco.<br>7 Coffin. | ... |
| ... | ... | Elesco<br>Coffin. | ... |
| ... | ... | No results available. | ... |
| ... | ... | ... | ... |
| ... | ... | .. | ... |

| QUESTION. | Malaysia. | |
|---|---|---|
| | Federated Malay States Railways. | |
| Chapter III *(continued)*. | | |
| C. — **Exhaust steam feed water heaters, feed-water passing through tubes heated on outside by exhaust steam.** | ... | ... |
| a) *Steam driven pump* . . . . . . . . | ... | C—a) Steam driven pump |
| b) *Mechanically driven pump* . . . . . | ... | ... |
| c) *Rotary pump, steam or mechanically driven.* | ... | ... |
| 1. *Number of engines fitted* . . . . . . . | 20 « L » class. | 746 |
| 2. *Name of Makers of feed water heater* . . | Weir. | Kawasaki<br>Osaka, Kisha Seizo Kaish<br>Mitsubishi Dock Co.<br>Hitachi Engineering |
| 3. *Results of tests* . . . . . . . . . . . | ... | Each test is given in comp<br>Coal consumption<br>per 100 tonne-kilometr<br>—<br>Injector . . . . . . .<br>Heater . . . . . . .<br>Injector . . . . . . .<br>Heater . . . . . . . |
| 4. *Influence of heater on partial softening of water.* | ... | The influence of the |
| 6. *Has trouble due to formation of scale in the tubes been experienced with the use of type C?* | No | |

| Japan. | | |
|---|---|---|
| panese Government Railways. | | Government General of Chosen. |
| Mechanically driven.<br>type was used for some en-<br>es, but the maintenance was<br>easy as troubles due to ex-<br>sive water pressure created by<br>mechanically driven pump<br>ld not be overcome. | C—a) Steam driven pump:<br>Special exhaust steam heaters in which exhaust steam passes through tubes and heats feed water in tank which is situated and partitioned in tender, hot water being pumped by steam pump. | ... |
| ... | ... | .. |
| ... | ... | ... |
| ... | ... | .. |
| ... | 94 | 1 |
| Nihonsharyo Kaisha. | ... | Superheater Co., U. S. A. |
| an injector and gives nearly same result for each type.<br>Water consumption<br>per 100 tonne kilometres.<br>47.4<br>45.0<br>12.3<br>10.0 | Average temperature<br>of feed water.<br>90° C. } On up grade of rat.25/1000<br>92° C.<br>85° C. } on level.<br>87° C. | No economy in coal and water consumption experienced comparable with engines of the same type equipped with ordinary injector. |
| e partial softening of the feed water before its introduction into<br>boiler is not known numerically. | | No information available. |
| o trouble has been encountered. | | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland & Scottish Railw |
| Chapter III *(continued).* | | | |
| D : **Exhaust steam feed water heaters in which exhaust steam comes into direct contact with feed water.** | | | |
| 1. *Number of engines fitted* . . | Two 4-6-2 type.<br>Eleven 2-10-0 type. | Nil. | 6 old type.<br>2 new type. |
| 2. *Name of Makers of feed water heaters.* | Worthington Pump Co.<br>Yamamoto Pump Factory. | ... | Dabeg. |
| 3. *Results of tests* . . . . . | *Worthington—Coal.*<br>4.4 lb. per 100 ton-miles, with pump.<br>4.62 lb. per 100 ton-miles, injector.<br>*Water :*<br>33.6 lb. per 100 ton-miles, pump.<br>32.5 lb. per 100 ton-miles, injector.<br>*Average temperature :*<br>97° C.<br>*Yamamoto—Coal.*<br>4.73 lb. per 100 ton-miles, with pump.<br>5.31 lb. per 100 ton-miles, injector.<br>*Water :*<br>26.6 lb. per 100 ton-miles, with pump.<br>37.8 lb. per 100 ton-miles, injector.<br>*Average temperature :*<br>66° C. | ... | Old type gave<br>8-9 % saving.<br>Difficulty with val<br>No results of new ty |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| London & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| nd 2.<br>C. F. I. fitted to:<br>iree 4-6-0 express passenger;<br>vo 4-4-2 express passenger;<br>vo 4-6-2 express passenger; | 198 | ... | ... |
| thington fitted to:<br>ne 2-8-0 mineral;<br>ne 4-6-0 passenger;<br>ne 4-4-2 passenger.<br>eg fitted to one 2-8-0 ineral one 4-4-2 passenger. | 54 Weir pumps.<br>144 Crosshead pumps. | Drummond feed water heater. | ... |
| C. F. I. gave economy f 10 % fuel on ton-ile basis. | No comparative tests. | Pumps unreliable.<br>Apparatus removed. | ... |
| rthington economy of % fuel on ton-mile asis. | No difference compared with injector. | | |
| eg gave economy of to 8 % fuel on ton-ile basis. | | | |
| rage temperature of ed water heater:<br>50° F. — Dabeg.<br>03° F. — Worthington.<br>08° F. — A C. F. I. | | | |

| QUESTION. | China *(continued)*. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midla & Scottish Rail |
| 4. *Influence of heater on partial softening of water.* | ... | ... | ... |
| 5. a) *What type of oil separator is used?* | a) *Worthington.*<br>Centrifugal.<br>*Yamamoto.*<br>Sumiyama oil separator. | .. | ... |
| b) *What amount of oil remains in the steam after passing through the separator?* | .. | ... | ... |
| c) *Has this led to any ill effects?* | ... | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Government Railw |
| Chapter III *(continued)*. | | | |
| **D : Exhaust steam feed water heaters in which exhaust steam comes into direct contact with feed water.** | | | |
| 1. *Number of engines fitted* . . | ... | 1 | ... |
| 2. *Name of Makers of feed water heater.* | ... | Worthington-Simpson. | .. |
| 3. *Results of tests* . . . . . | ... | Fitted for test purposes but the gain in efficiency was not considered such as to warrant the additional complication and cost of upkeep. | ... |
| 4. *Influence of heater on partial softening of water.* | ... | ... | ... |
| 5. a) *What type of oil separator is used?* | ... | ... | ... |
| b) *What amount of oil remains in the steam after passing through the separator?* | ... | ... | ... |
| c) *Has this led to any ill effects?* | ... | ... | ... |

## Great Britain and North of Ireland (*continued.*).

| don & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
|---|---|---|---|
| No figures available. | ... | ... | ... |
| Dabeg : Dabeg type.<br>— Worthington : Worthington type.<br>A. C. F. I. : Multiple Vee plate.<br>Negligible. | None. | ... | ... |
| No. | No. | ... | ... |

| Australasia | | Canada. | India |
|---|---|---|---|
| New South Wales overnment Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| .. | .. | 113. | ... |
| ... | ... | Worthington. | ... |
| .. | ... | No results of tests. | ... |
| ... | ... | . | .. |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | Malaysia. |
|---|---|
| | Federated Malay States. |
| Chapter III *(continued).* | |
| D. — **Exhaust steam feed water heaters in which the exhaust steam comes into direct contact with the feed water.** | |
| 1. *Number of engines fitted* . . . . . . . . . . | 2. |
| 2. *Name of Makers of feed water heater* . . . . . | Worthington-Simpson driven by steam pump |
| 3. *Results of tests* . . . . . . . . . . . . . . | ... |
| 4. *Influence of heater on partial softening of water* . | ... |
| 5. a) *What type of oil separator is used with feed water heaters of type D?* | Maker's patent. |
| b) *What amount of oil remains in the steam after passing through the separator?* | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London, Midland & Scottish Railway |
| Chapter III *(continued).* | | | |
| 7. *Of types of feed water heaters tested, which is preferred, with reasons.* | No reply. | No reply. | Exhaust steam inject preferred on accou of simplicity and lov cost and maintenar |

| Japan | |
|---|---|
| Japanese Government Railways. | Government General of Chosen. |
| Open exhaust steam feed water heaters in which exhaust steam blown from special nozzle, comes into contact with feed water in tank, which is situated and partitioned in tender and the hot water is supplied to boiler by steam driven pump. | |
| 294. | 1. |
| Japanese Government repairing works.<br>Kawasaki Manufacturing Company.<br>Mitsubishi Dock Yard Company.<br>Osaki Kisha Seizo Kaisha.<br>Hitachi Engineering Company.<br>Nihonsharyo Kaisha. | Worthington-Simpson heater. |
| Results of tests similar to those reported for feed water heaters of C type. | No economy in coal and water compared with engines equipped with injectors. |
| Not known numerically. | No information. |
| Oil separator is a rectangular vessel which contains several special guide vanes and a towel. The direction of steam flow is changed by the guide vanes and oil is separated. The remaining oil is absorbed by the towel when the steam passes through it. It is required to renew the towel often. This separator can be used without towel.<br>Some tests show that oil content in exhaust steam passed the separator with towel is : $\frac{0.7}{100\,000}$ to $\frac{0.8}{100\,000}$ | Worthington Feedwater Co's type. |

| Great Britain and North of Ireland | | | |
|---|---|---|---|
| London & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| As regards feed water heaters properly speaking there is still insufficient experience to state which design is giving the best results. | Exhaust steam injector preferred for a number of reasons :<br>Simplicity.<br>Absence oi moving parts.<br>Light weight.<br>Compactness.<br>Reliability.<br>Small cost and upkeep.<br>Readily changed without detaining engines in shed, etc. | ... | ... |

| QUESTION. | **Africa.** | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Governmen Railways. |
| Chapter III *(continued).*<br>7. *Of types of feed water heaters tested, which is preferred, with reasons.* | No reply. | No reply. | No reply. |
| | **India** *(continu* | | |
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Peninsula Railwa |
| | No reply. | No reply. | No reply. |
| | Japanese Gove | | |
| | Type C-a. — Closed type exhaust steam feed water heaters, driven by p steam driven.<br>Type C-b. — Exhaust steam feed water heaters driven by mechanically d pump.<br>Type C'a. — Special exhaust steam feed water heaters, heating water pa tioned in tender, driven by steam pump. | | |

| QUESTION. | |
|---|---|
| Chapter IV. — **Particulars of air preheating.** | No Railways reported any experiments with air preheating. |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| No reply. | No reply. | No reply. | No reply. |

| | | Malaysia. |
|---|---|---|
| Madras & Southern Mahratta Railway. | South Indian Railway. | Federated Malay States Railways. |
| No reply. | No reply. | Results from direct contact type have not been obtained as yet. |

| Japan. | |
|---|---|
| t Railways. | Government General of Chosen. |
| C (steam driven pump) is preferable for main line through working, ccount of simplicity in handling, fewness of troubles and good saving oal consumption. The heaters of types C'a and D contain a much er quantity of hot water than type C (steam driven pump). This good effects on coal saving for local train service as the hot water is lable when engine is drifting (very frequently in mountainous dis-s) or starting after long and frequent stops. For local train service is preferred to the type C on account of the above mentioned reason and preferable to type D by reason of easier handling and maintenance. | No reply. |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria. Railway. | Great Western Railway. | London, Midland & Scottish Railwa |
| Chapter V. — **Valves and valve gears.** | | | |
| 1. *Give particulars of any improved form of steam distribution valves and exhaust valves such as poppet valves, etc., introduced since 1922, and results obtained as regards :*<br>a) *Steam economy* . . . . .<br>b) *Reduction in maintenance* .<br>c) *Improved accessibility* . . . | No reply. | No reply. | Originally one Claug type 4-6-0 express senger engine was ed with Caprotti v gear. In compar with another engi the same class, ga saving of 22 %. further engines been fitted with improved boiler, Caprotti valve g These engines being tested aga similar engines, fitted with W schaerts valve gea |
| 2. *Give particulars of any improved form of valve gear introduced since 1922, and give the following information :*<br>a) *Table of valve events* . . .<br>b) *Results obtained and comparison made with locomotives fitted with ordinary type of valve gear.*<br>c) *Comparative cost of running maintenance.* | ... | ... | The following stand engines have long vel Walschaerts v gear :<br>Royal Scot 4-6-0 pas ger.<br>2-6-0 tender mixed t fic.<br>2-6-4 passenger tank<br>b) The above eng have proved econ cal and can be wo with a high expan ratio without exces compression and ro riding. We have engines of the s type with short v travel and run under similar co tions to obtain exact comparison ei in coal consump or maintenance. |

## Great Britain and North of Ireland.

| ondon & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
|---|---|---|---|
| | | | |
| entz poppet valve with oscillating drive have been fitted to a number of engines of recent design. These have given satisfaction.<br>entz poppet valves driven by a rotating cam shaft have been fitted to two 3-cylinder engines of the 4-4-0 type.<br>express passenger engines of the 4-6-0 type are being fitted with Caprotti valve gear. No definite results are yet to hand. | Have not adopted any form of poppet valve. | ... | No change has been made in valves or valve gears since 1922, but standard piston valves with Walschaerts gear have been used. |
| onger valve travel together with increased lap has resulted in coal economy with 4-6-2 express passenger engines.<br>) See tables III and IV giving valve events.<br>) No results yet available. | Long travel piston valves in conjunction with the ordinary Walschaerts or Stephenson valve gear have been used for new engines since 1917. | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Governmen Railways. |
| Chapter V *(continued)*. | | | |
| 1. *Give particulars of any improved form of steam distribution valves and exhaust valves such as poppet valves, etc., introduced since 1922 and results obtained as regards :* | Lentz poppet valves are fitted to some of the more recently built locomotives and are still under trial. | Lentz poppet valves were fitted to one engine. The results obtained were not outstanding, as trouble was at first experienced with broken valves although this fault now appears to have been overcome. Dynamometer car tests indicated little if any advantage over piston valves at the temperature and pressure used on the engine in question. | None fitted. |
| a) *Steam economy* . . . . . | ... | ... | ... |
| b) *Reduction in maintenance* . | ... | ... | ... |
| c) *Improved accessibility* . . . | ... | ... | ... |
| 2 *Give particulars of any improved form of valve gear introduced since 1922, and give the following information :* | ... | The standard valve gear is of the Walschaerts type and no other type has been introduced since 1922. | ... |
| a) *Table of valve events* . . . | ... | ... | ... |
| b) *Results obtained and comparison made with locomotives fitted with ordinary type of valve gear.* | ... | ... | ... |
| c) *Comparative cost of running maintenance.* | ... | ... | ... |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| None fitted. | No experiments have been carried out with poppet valves, the valve gears in use being Walschaerts and Stephenson. | None fitted. | None fitted. |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | Dunn long travel. | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | Eastern Bengal Railway. | East Indian Railway. | Madras & Souther Mahratta Railway |
|---|---|---|---|
| Chapter V *(continued).* | | | |
| 1. *Give particulars of any improved form of steam distribution valves and exhaust valves such as poppet valves, etc., introduced since 1922, and results obtained as regards :* | No remarks. No improved form of valve or valve gear introduced. | None fitted. | Regret we have not b permitted to introd poppet valves or a improved form steam distribution b ond the ordinary W schaerts gear with p ton valves. |
| a) *Steam economy . . . . .* | ... | ... | ... |
| b) *Reduction in maintenance .* | ... | ... | ... |
| c) *Improved accessibility . . .* | ... | ... | ... |
| 2. *Give particulars of any improved form of valve gear introduced since 1922, and give the following information :* | ... | ... | Nil. |
| a) *Table of valve events . . .* | ... | ... | ... |
| b) *Results obtained and comparison made with locomotives fitted with ordinary type of valve gear.* | ... | ... | ... |
| c) *Comparative cost of running maintenance.* | ... | ... | ... |

| tinued). |  | Malaysia. | Japan. |  |
|---|---|---|---|---|
| Great Indian uinsula Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| ıe in use at pre- ›nt, but some trial ›ts of Lentz valves ıave been ordered ›r goods and pas- ›nger locomotives. | No experiments on the lines indicated. | It is proposed to adopt Caprotti valve gear. | Nil. | Nil. |
| ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |
| ... | No improvements have been made on the standard Walschaerts valve gear at present in use. | Walschaerts gear is in use with Gresley drive for the centre cylinder in 3-cylinder locomotives. | Nil. | Nil. |
| ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railways. | Great Western Railway. | London, Midlan & Scottish Railw |
| Chapter VI. — **Arrangement of front end.** | | | |
| 1. *Submit drawing of standard smokebox layout.* | ... | ... | ... |
| 2. *Give particulars of any experimental blast pipe arrangements in use. And results of experiments on :* | Nothing to report. | Experiments are being carried out with Kylala blast pipe on express passenger engines. | ... |
| a) *Smoke box vacuum . . . .* | 4″ of water at the outside of diaphragm.<br>2 3/8″ of water at inside of diaphragm. | ... | ... |
| b) *Size of chimney and petticoat pipe.* | Size of chimney determined from boiler horse power. | ... | ... |
| c) *Height of top of blast pipe nozzle above or below centre line of boiler.* | ... | ... | ... |
| d) *Height of chimney at smallest diameter above centre line of boiler.* | ... | ... | ... |
| e) *Have any modifications been made to the front end to prevent steam being beaten down along the barrel.* | ... | ... | Tests have been n with a wind scoop ted at the back of chimney with the ject of lifting the s ke, and this has b partially successfu |

**Great Britain and North of Ireland.**

| London & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
|---|---|---|---|
| periments are being carried out with Kyla-a blast pipe and an improved form of Kyala blast pipe known as Kylala-Chapelon. Results so far satisfactory. | ... | No reply. | ... |
| ... | No experiments. | .. | No experiments. |
| periments between 2-cylinder and 3-cylinder engines have shown that a more even vacuum resulting in coal economy is obtained with 3-cylinder engines. | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | Various deflectors tried in front or behind chimney, but no benefit found. Most effective means of lifting smoke and exhaust steam is by means of vertical plates on each side of smoke box, fixed near outside of platforms (see fig. 15). | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Governme Railways. |
| Chapter VI *(continued).* | | | |
| 1. *Submit drawing of standard smokebox layout.* | ... | ... | ... |
| 2. *Give particulars of any experimental blast pipe arrangements in use. And results of experiments on :* | No experiments. | ... | Lewis blast pipe has<br>installed on two<br>*do* type engines<br>ing heavy slow tr<br>These engines sho<br>slight economy in<br>consumption ove<br>similar engine nc<br>fitted. |
| a) *Smoke box vacuum . . . .* | ... | ... | ... |
| b) *Size of chimney and petticoat pipe.* | ... | ... | ... |
| c) *Height of top of blast pipe nozzle above or below centre line of boiler.* | ... | ... | ... |
| d) *Height of chimney at smallest diameter above centre line of boiler.* | ... | ... | ... |
| e) *Have any modifications been made to the front end to prevent steam being beaten down along the barrel?* | ... | No modifications have been tried in order to prevent the steam being beaten down along the barrel. | ... |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| ... | ... | ... | ... |
| xperimental blast pipes have not been fitted. | No experiments have been carried out. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | India *(contin* | | |
|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Peninsula Railwa |
| Chapter VI *(continued).* | | | |
| 1. *Submit drawing of standard smokebox layout.* | ... | Front end of all our classes of locomotives designed to Goss's formula which has been adopted and proved very satisfactory. | ... |
| 2. *Give particulars of any experimental blast pipe arrangements in use. And results of experiments on :* | No experiments. | ... | No experiments. |
| a) *Smoke box vacuum . . . .* | ... | ... | ... |
| b) *Size of chimney and petticoat pipe.* | ... | ... | ... |
| c) *Height of top of blast pipe nozzle above or below centre line of boiler.* | ... | ... | ... |
| d) *Height of chimney at smallest diameter above centre line of boiler.* | ... | ... | ... |
| e) *Have any modifications been made to the front end to prevent steam being beaten down along the barrel?* | ... | ... | ... |

| | | Malaysia. | Japan. | |
|---|---|---|---|---|
| lras & Southern hratta Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| ... | ... | ... | ... | ... |
| ... | No experiments. | Experiments have been carried out with locomotives fitted with jumper caps. The height of the blast pipes has been considerably reduced, giving fuel economy. Mean fuel consumption per 100 ton-miles :<br>20.9 old pattern long pipe.<br>16.5 short pipe and jumper cap. | Experiments have been carried out, the sizes of blast nozzle and chimney being designed according to the formula of Strahl and Von Borrie. The results of both designs practically coincided. Experiments on several different shapes of cross section of blast pipe have been carried out but no better result was obtained than with that of circular section. Circular section adopted as standard. | ... |
| ... | ... | ... | ... | ... |
| ... | ... | b) *Long pipe :*<br>Chimney smallest diameter 12″.<br>Petticoat-nil.<br>*Short pipe :*<br>Chimney smallest diameter 12″.<br>Petticoat-10 7/8″. | ... | .. |
| ... | ... | c) *Long pipe :*<br>1′-3/8″ (above).<br>*Short pipe :*<br>1 7/8″ (above). | ... | ... |
| ... | ... | d) Long pipe :<br>3′-4 11/16″.<br>*Short pipe :*<br>2′-2 7/8″ at the waist of petticoat.<br>*Note :* Lignite coal of 9 000-10 000 B.T.U | ... | ... |
| ... | ... | ... | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland Scottish Railw |
| Chapter VII. — **Miscellaneous.**<br>A. — **Compounding.** | | | |
| 1. *What system of compounding, if any, has been made standard, and give particulars, as follows :* | No reply. | No reply. | The following parti apply to 4-4-0 sta compounds whic a standard class L. M. S. for e work with trai moderate weight. |
| a) *Number of H. P. and L. P. cylinders.* | ... | ... | 1 H. P. cylinder frames.<br>2 L. P. cylinders o frames.<br>H. P. 19″ × 26″.<br>L. P. 21″ × 26″. |
| b) *Ratio of diameters . . .* | ... | ... | Ratio : 1 : 2.4 |
| c) *Volume of clearance space.* | ... | ... | 16 % H. P. cylind<br>9 % L. P. cylin |
| d) *Valves gears used either joint or separate.* | ... | ... | 3 separate sets of phenson gear. |
| e) *Cut off in H. P. and L. P. cylinders.* | ... | ... | Full gear 87 % H<br>80 % L<br>Both gears controll one lever. |
| f) *Steam pressure used . .* | ... | ... | 200 lb. per square |
| 2. *Give results of any trials and especially :* | | | |
| a) *Saving of fuel . . . . .* | ... | ... | 18 % to 20 % of over simple engi similar power. |
| b) *Saving of water . . . .* | ... | ... | ... |
| c) *Effect on maintenance cost.* | ... | ... | No exact data. |
| 3. *Give particulars of maintenance and first cost.* | ... | ... | We have no exactly lar class of simp gine with whic make a compariso |
| 4. *Are experiments being made?* | ... | ... | No. The 4-4-0 comp is a standard e for certain clas work. |
| 5. *Have experiments enabled any decision to be arrived at?* | ... | ... | ... |
| 6. *Is intermediate superheating being done?* | ... | ... | No intermediate s heating tried. |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| London & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| No system of compounding has been made standard. | None in use. | No reply. | No modern compounds have been built on this line, but there are a number of two-cylinder Worsdell-Von Borrie type in use, but these cannot be considered modern designs and details are consequently not given. |
| ... | .. | ... | ... |
| .. | ... | ... | ... |
| .. | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| .. | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Governmen Railways. |
| Chapter VII. — A. **Compounding.** *(Continued.)* | | | |
| 1. *What system of compounding, if any, has been made standard, and give particulars, as follows :* | No compounds in use. | Apart from *Mallet* engines, compounding is not used. No *Mallets* have been ordered since 1922. | No compounds in u |
| a) *Number of H. P. and L. P. cylinders.* | ... | ... | ... |
| b) *Ratio of diameters . . .* | ... | ... | ... |
| c) *Volume of clearance space.* | ... | ... | ... |
| d) *Valves gears used either joint or separate.* | ... | ... | ... |
| e) *Cut off in H. P. and L. P. cylinders.* | ... | ... | ... |
| f) *Steam pressure used . .* | ... | ... | ... |
| 2. *Give results of any trials and especially :* | | | |
| a) *Saving of fuel . . . . .* | ... | ... | .. |
| b) *Saving of water . . . .* | ... | ... | ... |
| c) *Effect on maintenance cost.* | ... | ... | ... |
| 3. *Give particulars of maintenance and first cost.* | | | |
| 4. *Are experiments being made?* | | | |
| 5. *Have experiments enabled any decision to be arrived at?* | ... | 4-cylinder simple Garratt engines are preferred. | ... |
| 6. *Is intermediate superheating being done?* | No. | No. | No. |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| No compounds in use. | Two classes of compounds : A and X classes. | Only two engines compounded. | None in use. |
| ... | 2. H. P. and 2. L. P. | ... | ... |
| ... | *A class*<br>H. P. 12″; L. P. 19″.<br>*X class :*<br>H.P. 12 1/2″; L.P. 22″. | ... | ... |
| ... | ... | ... | ... |
| ... | Valve gears for high and low pressure cylinders on each side being driven through one arm. Walschaerts valve gear.<br>Two separate sets of reversing levers used so that cut off can be varied independently. | ... | ... |
| ... | ... | ... | ... |
| ... | *Class A* — 225 lb.<br>*Class X* — 230 lb. | ... | ... |
| ... | Trials which have been carried out with A class compound locomotive shew that the simple locomotive has been more economical in all departments, but the trials were not of a conclusive nature as the simple engine was fitted with a superheater whereas the coumpound was not superheated. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | The Railway Company prefers simple locomotives to compound locomotives. | ... | ... |
| No. | No. | ... | ... |

| QUESTION. | India *(contin* | | |
|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Peninsula Railwa |
| Chapter VII. — A. **Compounding.** *(Continued.)* | | | |
| 1. *What system of compounding, if any, has been made standard, and give particulars, as follows :* | No compounds in use. | None in use. | None in use. |
| a) *Number of H. P. and L. P. cylinders.* | ... | ... | ... |
| b) *Ratio of diameters . . .* | ... | ... | ... |
| c) *Volume of clearance space.* | ... | ... | ... |
| d) *Valve gears used either joint or separate.* | ... | ... | ... |
| e) *Cut off in H. P. and L. P. cylinders.* | ... | ... | ... |
| f) *Steam pressure used . .* | ... | ... | ... |
| 2. *Give results of any trials and especially :* | | | |
| a) *Saving of fuel . . . . .* | ... | ... | ... |
| b) *Saving of water . . . .* | ... | ... | ... |
| c) *Effect on maintenance cost.* | ... | ... | ... |
| 3. *Give particulars of maintenance and first cost.* | ... | ... | ... |
| 4. *Are experiments being made?* | ... | ... | ... |
| 5. *Have experiments enabled any decision to be arrived at?* | ... | ... | ... |
| 6. *Is intermediate superheating being done?* | ... | ... | ... |

| | | Malaysia. | Japan | |
|---|---|---|---|---|
| adras & Southern ahratta Railway. | South Indian Railway. | Federated Malay States Railway. | Japanese Government Railways. | Government General of Chosen. |
| None in use. | No experiments on the lines indicated. | 2 *Mallet* articulated compounds. | A few *Mallet* compounds. | 6 compounds made by Baldwin in 1906. |
| ... | ... | 2. H. P. - 2. L. P. | ... | 2. H. P. - 2. L. P. |
| ... | ... | H. P. 13″ - L. P. 19″. | ... | L. P. : H. P. 25″ 15″ — 1.665. |
| ... | ... | ... | ... | H. P. 66 cubic inches.<br>L.P. 184 cubic inches. |
| ... | ... | Gear jointly operated by one reversing lever. | ... | Stephenson joint type. |
| ... | ... | ... | ... | H. P. 84 % full gear. |
| ... | ... | 180 lb. | ... | 200 lb. |
| ... | ... | Mallet, consumption lignite coal.<br>14.6 lb. per 100 ton-miles.<br>Standard superheater Pacific, 16.5. | ... | No trials of which result may be of practical interest. |
| ... | ... | Mallet, 11.2 per 100 ton-miles.<br>Superheater, 6.6 per 100 ton-miles. | ... | ... |
| ... | ... | Mileage between repairs (heavy) :<br>Mallet, 59 256.<br>Average superheater, 75 428. | ... | ... |
| ... | ... | ... | ... | ... |
| No. | ... | ... | ... | ... |
| No. | ... | ... | No standard has been made. | ... |
| ... | ... | ... | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland & Scottish Railway. |
| Chapter VII. — B. **Combustion in fireboxes.** | | | |
| 1. *Please give particulars and results of any experiments on :* | ... | ... | Langer system of c bustion control is be tried on one engi steam blown into f box to improve tur lence. |
| a) *Ash pan openings* . . . . | ... | ... | No experiments. |
| b) *Grate openings or firebar spacing or special type of firebar.* | Finger grate bar 3/4" spacing. | ... | Air spaces through grates of standard gines are about 35 of grate area. |
| c) *Brick arches* . . . . . . | ... | ... | ... |
| d) *Supplementary air through arch.* | ... | Nil. | No recent experiment |
| e) *Brick arch tubes* . . . . . | ... | Nil. | Not used. |
| f) *Supplementary air through back plate.* | Opening between the back plate of inner firebox and the back end of brick arch is 2.5 to 3 times the gas area. | Nil. | No experiments. |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| Southern Railway. | London & North Eastern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| ... | ... | No reply. | No experiments. |
| o experiments made. 15 % of grate area provided. | ... | ... | ... |
| paces about 7/16" for 3/4" bars usual. Special forms of firebar not found to give increase in economy. | Drop grates have been fitted to a number of engines of recent design to enable firebox to be easily cleaned. | ... | ... |
| o extensive experiments made. | ... | ... | ... |
| None. | ... | ... | ... |
| None. | ... | ... | ... |
| little air admitted through fire hole. | ... | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesia Railways. | South African Railways. | Sudan Government Railways. |
| Chapter VII. — **B. Combustion in fireboxes.** *(Continued.)* | | | |
| 1. *Please give particulars and results of any experiments on :* | No results available. | ... | No results available |
| a) *Ash pan openings* . . . . | ... | Ash pan openings made variable. | ... |
| b) *Grate openings or firebar spacing or special type of firebar.* | ... | ... | ... |
| c) *Brick arches* . . . . . . . | ... | ... | ... |
| d) *Supplementary air through arch.* | ... | No air openings are provided in arch itself, which on later engines is supported on arch tubes. | ... |
| e) *Brick arch tubes* . . . . . | ... | ... | ... |
| f) *Supplementary air through back plate.* | ... | Air does not enter through openings in the back plate other than by means of the fire door when open. | ... |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales<br>vernment Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| esign which provides<br>r 1 square foot of<br>umper opening to<br>sq. feet of grate area<br>as been found most<br>tisfactory. It was<br>nsidered advisable to<br>tain this ratio by<br>tting vents in each<br>de of ash pan to<br>pplement the area of<br>umper opening on cer-<br>in classes of engines. | The Railway Department has found that the provision of openings at sides of ashpan under foundation ring, in addition to the front and back ash pan doors has given most beneficial results. | ... | ... |
| ... | ... | 15 % of grate area for ash pan openings. | ... |
| king grates of box<br>esign are fitted with<br>raight cast iron bars,<br>e former being locat-<br>l in the front end of<br>x. A drop grate is<br>corporated to facili-<br>te cleaning of the<br>re. Space between<br>rebars 7/8" to 1 1/8". | Standard spacing is 3/16". | ... | ... |
| rick arch is fitted in<br>e firebox of all loco-<br>otives in service, and<br>supported on studs<br>rewed into each side<br>eet. | Brick arches carried well back towards the door are employed. | ... | ... |
| vision is not made to<br>duce supplementary<br>r through the arch,<br>t a small opening is<br>ade in front on each<br>de through which<br>rticles of small coal,<br>hes, etc., may fall<br>ck on the fire grate. | Supplementary air is not carried through the arch. | ... | ... |
| k arch tubes are<br>t at present fitted. | Arch tubes are not employed. | ... | ... |
| Not provided. | Supplementary air is not carried through the back plate excepting through vents in the fire doors. | ... | ... |

| QUESTION. | India (continu | | |
|---|---|---|---|
| | Eastern Bengal Railway. | East Indian. Railway. | Great Indian Peni Railway. |
| Chapter VII. — **B. Combustion in fireboxes.** *(Continued.)* | | | |
| 1. *Please give particulars and results of any experiments on :* | ... | No results. | No results. |
| a) *Ash pan openings* . . . . | ... | ... | ... |
| b) *Grate openings or firebar spacing or special type of firebar.* | ... | ... | Rocking grate 1 1/8’ spacing. |
| c) *Brick arches* . . . . . . . | ... | ... | ... |
| d) *Supplementary air through arch.* | ... | ... | ... |
| e) *Brick arch tubes* . . . . . | A few engines with brick arch tubes have been put into service, but no results available. | ... | Security arch tube been fitted, but no sults available. |
| f) *Supplementary air through back plate.* | ... | ... | ... |

| | | Malaysia. | Japan. |
|---|---|---|---|
| Madras & South Mahratta Company. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. |
| No results. | ... | ... | ... |
| ... | ... | ... | Ash pan opening 15 % of grate area for new locomotives. Some experiments show that the larger the opening the better. |
| ... | ... | Rocking grates fitted on S. class engines. | ... |
| ... | Brick arch, etc., under trial. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | Arch tube adopted as standard. | ... |
| ... | ... | ... | Supplementary air through back plate is not usually supplied. Experiments tried with fire hole door open resulted in good saving of coal when engine was working hard Found not to be practical owing to radiant heat from fire making fireman suffer. Usual practice « One hand » shovelling to minimise volume of air through firehole door. |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland Scottish Railwa |
| Chapter VII. — C. **Circulation in boilers.** | | | |
| *Has any device been tried to improve the circulation of the water in the boiler, such as : Arch tubes, thermic syphons, etc.* | Two 2-10-0 type engines equipped with Nicholson thermic syphon. | No results. | In 1924 a thermic sy was fitted to a Claughton class gine. |
| *Give results of tests and give particulars of effect on the first cost and cost of maintenance.* | By stationary tests the thermic syphon proved to be more effective than arch tubes, but by running tests there was found to be no difference between them. | | Considerable trouble experienced due leakage at the flange joints, and it was ta out. Arrangements are being made for fur tests with thermic syphons as used in Ame (United States) with a view to ascertai whether on the narrow fireboxes of the L. M it would show any advantage. |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Government Railways. |
| Chapter VII. — C. **Circulation in boilers.** *(Continued.)* | | | |
| *Has any device been tried to improve the circulation of the water in the boiler, such as : Arch tubes, thermic syphons, etc.* | Four arch tubes have been fitted in the firebox of our latest type of locomotive. | Arch tubes fitted to some of the later type engines. | None fitted. |
| *Give results of tests and give particulars of effect on the first cost and cost of maintenance.* | It is noticeable that the boilers steam more freely. | No exact tests have been made. | |
| *Effect on boiler cleanliness . . .* | | | ... |
| *Any economies resulting . . . .* | Life of brick arch is considerably increased by support of the arch tubes. | Have not been in service long enough to enable particulars of cost of maintenance or resulting economies to be obtained. | |
| *Particulars of any increase in boiler capacity.* | ... | ... | ... |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| ndon & North Eastern Railway. | Southern Railway. | Great Northern of Ireland | London Midland & Scottish Railway (Northern Counties Committee). |
| ... | No circulation devices such as arch tubes or thermic syphons. | No reply. | No special devices tried. |
| ... | ... | ... | ... |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| o action in this direction has been taken. | No experiments have been carried out. Nicholson thermic syphons are being fitted to some locomotive boilers which are shortly to be placed in service. | Arch tubes are in general use. A number of engines fitted with thermic syphons which are giving satisfaction. | No reply. |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | India (contin | | |
|---|---|---|---|
| | East Indian Railway. | Eastern Bengal Railway. | Great Indian Pen Railway. |
| Chapter VII. — C. **Circulation in boilers.**<br>*(Continued.)* | | | |
| *Has any device been tried to improve the circulation of the water in the boiler, such as :* | ... | None fitted. | ... |
| *Arch tubes, thermic syphons, etc.* | Arch tubes. | ... | Security arch tubes been fitted to new gines just receive |
| *Give results of tests and give particulars of effect on the first cost and cost of maintenance.* | No reports received. | ... | No data is availab |
| *Effect on boiler cleanliness . . .* | ... | ... | ... |
| *Any economies resulting . . . .* | ... | ... | ... |
| *Particulars of any increase in boiler capacity.* | ... | ... | ... |

| | | Malaysia. | Japan. | |
|---|---|---|---|---|
| lras & Southern ratta Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| ... | ... | ... | ... | ... |
| Arch tubes. | Arch tubes fitted, primarily for carrying the brick arch. | Arch tubes fitted on Q.K. and S. class engines. | Some engines fitted with 3 arch tubes of 3" outside diameter. | Almost all boilers are equipped with arch tubes. |
| special tests have een carried out. | No tests have been conducted. | ... | The first and maintenance cost is not high. | ... |
| ... | ... | ... | Effect on circulation of water, boiler cleanliness, and boiler capacity is not known numerically. | ... |
| h tubes have given rouble with bulg ng.<br>t data not available. | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midlan Scottish Railw |
| Chapter VII. — D. **Regulators.** | | | |
| *Describe any new arrangement of regulator adopted since 1922 and attach the necessary explanatory drawings.* | None tried. | No new regulators tried. | Five engines fitted « Owen » type r tor. (See fig. 1 |
| *Give particulars of any improvement obtained both as regards ease and accuracy of control, steam tightness and freedom from wear.* | ... | ... | Easier to open than valves and less to breakage tha ordinary double Experiments of too duration as yet t particulars of we |
| *Have regulators controlling the steam on the superheated side been tried? If so, describe arrangement and give particulars of any additional stop cock on saturated side fitted.* | ... | ... | No trials have been with regulator bef the superheater the cylinders. |
| *What has been the practical result of this arrangement both as regards the regulator proper and as regards the superheater elements?* | ... | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | **Rhodesian Railway.** | South African Railways. | Sudan Governmen Railways. |
| Chapter VII. — D. **Regulators.** *(Continued.)* | No new types fitted. | No new types fitted. | No new types fitt |
| *Regulators on superheated side* . | ... | ... | ... |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| ndon & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| uble beat regulators, Owen, Joco, and Hulburd-Servo, have been tried. | No new types in use. Control from saturated side. | No reply. | No new regulator tried. |
| gulator trials too recent to express an opinion. | ... | ... | ... |
| ront end regulators are being fitted for trial. | ... | ... | ... |
| ... | ... | ... | ... |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| o action in this direction has been taken. | The standard used by the Railway is the double beat pattern. | ... | No reply. |
| ... | New locomotives having the Superheater Company's patented design of regulator embodied in the superheater header are being designed and will shortly be put into service. | Front end throttle incorporated in superheater header. | ... |

| QUESTION. | India *(contin* | | |
|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Penin Railway. |
| Chapter VII. — D. **Regulators.** *(Continued.)* | | | |
| *Describe any new arrangement of regulator adopted since 1922 and attach the necessary explanatory drawings.* | A balanced regulator of « Owens » type. | « Owens » balanced regulator valve. | « Owens » balanced r lators have been fi to the new stand type of locomotive |
| *Give particulars of any improvement obtained both as regards ease and accuracy of control, steam tightness and freedom from water.* | No data available. | Giving good results. | Giving satisfaction. |
| *Have regulators controlling the steam on the superheated side been tried? If so, describe arrangement and give particulars of any additional stop cock on saturated side fitted.*<br>*What has been the practical result of this arrangement both as regards the regulator proper and as regards the superheater elements?* | ... | ... | ... |

| | | Malaysia. | Japan. | |
|---|---|---|---|---|
| adras & Southern ahratta Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| uble beat valves have been tried. | « Owens » double beat valves have been fitted in some engines. | ... | With an ordinary port too much steam is apt to be admitted to cylinder at the beginning of stroke of regulator valve, and engine sometimes conveys certain shocks to train at starting. To prevent this, a port was experimentally enlarged so as to have gradual increase of its opening area at the beginning of its stroke. This gave good results, but the outline of the port is still under consideration. | None tried. |
| ase of operation undoubted.<br>ot enough experience to give particulars of wear. | Valves found not satisfactory owing to the fact that they continually leak. | ... | ... | ... |
| ... | ... | Regulator gear incorporated in header on S. class.<br>Too early to say effect.<br>A stop valve is fitted between boiler and header. The engines have only been in use a few months and no ill effects have yet been noticed. | ... | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland Scottish Railway |
| Chapter VII. — E. **Steam dryers.**<br>*Describe any arrangement of steam dryer which has been tried and attach necessary drawings.* | No reply. | None tried. | No steam separator dryers tried. |
| | **Africa.** | | |
| *Give particulars of any tests that have been made to ascertain the reduction in the amount of water present in the steam thrown out by such dryers.* | Rhodesian Railway. | South African Railways. | Sudan Governme Railways. |
| | No steam dryer or separator in use. | Tests with steam dryers have not proved successful. | No successful s dryer or separator been installed. |
| *Give particulars of any tests made to determine the effect of such steam dryers on superheat and fuel consumption.* | **India** *(continu* | | |
| | Eastern Bengal Railways. | East Indian Railway. | Great Indian Peninsula Railw |
| *Has the use of such separators had any effect on the life of the superheater elements?* | None in use. | None in use. | A tangential dryer tried on a passe engine, but as n preciable improve was noticed, the was removed. |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| ondon & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| Steam dryers have been tried. Tests showed no appreciable difference in the amount of water present in the steam thrown out by such dryers, probably due to lack of space available.<br>No results available. | Two types of steam dryer tried, but neither had any perceptible result on superheat, water or coal consumption when compared with engines not so fitted. The life of the elements is not affected. | No reply. | No trials. |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales Government Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| Steam dryers or separators have not been fitted. | No appliances have been tested out. | No reply. | No reply. |

| | | Malaysia. | Japan. | |
|---|---|---|---|---|
| adras & Southern ahratta Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| e are unable to distinguish between engines fitted and those not fitted. | No experiments have been conducted. | No reply. | No experience. | No experience. |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midland Scottish Railwa |
| Chapter VII. — **F. Soot blowers.** | | | |
| *Give particulars of soot blowers in use stating :* | ... | None fitted. | 53 engines inclu « Royal Scot » fitted with Dia<br>12 engines fitted Parry. |
| a) *Make* . . . . . . . . . | American Railway Appliance Company. | ... | Diamond soot bl<br>Parry soot blowe |
| b) *Position fitted* . . . . . | Left side of firebox. (driver's side). | ... | Back plate.<br>Back plate. |
| c) *Effect on roof, side and tube plates of box, brick arches and tubes.* | ... | ... | Under certain condi may cause exce wear of the fireb<br>Tube plate experienc shown that wea erosion only t place under certai cumstances. |
| d) *Effect on fire* . . . . . . | ... | ... | ... |
| e) *Instructions as to when blower should be used and time.* | ... | ... | ... |
| f) *Cost of repairs* . . . . . | ... | ... | ... |
| g) *Whether any saving in labour of tube cleaning at the sheds is effected.* | ... | ... | ... |

## Great Britain and North of Ireland.

| ndon & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
|---|---|---|---|
| ... | ... | No reply. | No trials. |
| iamond (see fig. 21).<br>Parry.<br>Clyde. | Diamond. | ... | ... |
| Back plate. | Back of firebox above firehole. | ... | ... |
| No effect. | Sweeps tube plate, tubes and top of arch. | ... | ... |
| Slight damping effect. | Not appreciable. | ... | ... |
| When working hard. | When engine is working hard at intervals. | ... | ... |
| Negligible. | So far as tried the repairs necessary have been very slight. | ... | ... |
| Yes. | It has been found that the effect of the blower is to stir up the accumulation on the top of the brick arch and deposit this in the tubes, thus nullifying the good effects which were at first anticipated from the use of this apparatus. Have now decided to discontinue the use of soot blowers. | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Governme Railways. |
| Chapter VII. — **F. Soot blowers.** *(Continued.)* | | | |
| *Give particulars of soot blowers in use stating :* | | | |
| a) *Make* . . . . . . . . . | Parry steam blower, locomotive type. | Parry steam blower. | 2 engines Diamond blower. |
| b) *Position fitted* . . . . . | Firebox backplate above firehole door. | Centre of backplate above firedoor. | ... |
| c) *Effect on roof, side and tube plates of box, brick arches and tubes.* | No detrimental effects as far as can be ascertained at present. | ... | ... |
| d) *Effect on fire* . . . . . . | When blower is applied no detrimental effect on fire is caused. | ... | ... |
| e) *Instructions as to when blower should be used and time.* | Blower only to be used when the fire is bright. It requires full boiler pressure and should be applied every 4 hours. It may be worked either with the locomotive standing or at full speed. | Blower is used once every hour for approximately one minute at a time. | Used when running a blows out a la amount of accumu ed soot. |
| f) *Cost of repairs* . . . . . | This type of blower has only been in service 6 months. No repairs have been necessary. | Apparatus not long enough in service to enable cost of upkeep to be ascertained. | ... |
| g) *Whether any saving in labour of tube cleaning at the sheds is effected.* | The blower keeps the boiler tubes, superheater tubes and smokebox perfectly clean and obviates the use of brushes, rods or compressed air. | The use of this fitting reduces considerably the shed work in cleaning. | Labour on tube cleani at sheds diminish but not entirely e minated. |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales overnment Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| None fitted. | Diamond. | Diamond Superior. | Diamond. |
| ... | Back plate. | Back of back tube sheet in sides of firebox. | Front of firebox. |
| ... | Results of tests not sufficiently conclusive to warrant its adoption. | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |

| QUESTION. | **India** *(contin* | | |
|---|---|---|---|
| | Eastern Bengal Railway. | East Indian. Railway. | Great Indian Peni Railway. |
| Chapter VII. — **F. Soot blowers.** *(Continued.)*<br>*Give particulars of soot blowers in use stating :* | | | |
| a) *Make* . . . . . . . . . | Parry soot blower.<br>Diamond. | Clyde Superior.<br>Diamond soot blower.<br>Parry. | Clyde Superior.<br>Diamond soot blow<br>Parry soot blowe |
| b) *Position fitted* . . . . . | Back plate. | Clyde (1) back plate.<br>Clyde (2) sides of firebox.<br>Diamond } back plate of<br>Parry } firebox. | Back of firebox. |
| c) *Effect on roof, side and tube plates of box, brick arches and tubes.* | No negative reports. | Results of trials not yet to hand. | These are experim and no results available at prese |
| d) *Effect on fire* . . . . . . . | During operation the fire is somewhat damped. | ... | ... |
| e) *Instructions as to when blower should be used and time.* | No special instructions. | ... | ... |
| f) *Cost of repairs* . . . . . | Not known. | ... | ... |
| g) *Whether any saving in labour of tube cleaning at the sheds is effected.* | A few engines so fitted have just been put into service. No figures available. | ... | ... |

| | | Malaysia. | Japan. | |
|---|---|---|---|---|
| dras & Southern hratta Railway. | South Indian Railway. | Federated Malay States Railways. | Japanese Government Railways. | Government General of Chosen. |
| lyde Superior. | Parry soot blower.<br>Clyde soot blower. | Sootblowers will be fitted to new engines. | No experience. | No experience. |
| ... | Each side of firebox on 16 engines, back plate on 4 engines. | ... | ... | ... |
| Nil. | Effect of blowers fitted on back plate has not been satisfactory owing to the jet of steam not being sufficiently powerful. Blowers fitted on sides of firebox clean the tubes satisfactorily, provided the brick arch does not interfere with the bottom row of tubes. | ... | ... | ... |
| Nil. | Blowers affect fire very considerably and it is necessary to use them after the fire has been made up. | ... | ... | ... |
| he end of a run d before leaving ed. | Blowers only to be used when regulator is shut. Amount of steam used together with interference with fire results in boiler pressure drop of 5 to 10 lb. after each application. | ... | ... | ... |
| available, but y small. | The blowers have only been recently introduced. | ... | ... | ... |
| no figures avail- le. | We have only 20 engines fitted, but if all engines were fitted a reduction in labour for cleaning tubes in sheds could undoubtedly be effected. | | ... | ... |

QUESTION.

## CHAPTER VII. — G. Boosters.

*Give particulars and send drawings together with pipe arrangement of boosters fitted . . .*

a) *To trailing carrying axles* . . . . . . . . . . . . . . . . . . . . . . . .

b) *To trailing bogies* . . . . . . . . . . . . . . . . . . . . . . . . .

c) *To tender bogies, and state number of engines* . . . . . . . . . . . . . . .

*To what extent has the booster :*

a) *Increased the speed?* . . . . . . . . . . . . . . . . . . . . . . . .

b) *Increased the load of trains worked by booster fitted engines?* . . . . . . . . . .

*Give particulars of any particular difficulties found in operation and maintenance, and steps taken to overcome them.*

*What effect has the booster had on the cost of maintenance and on the fuel consumption?* . .

*Give particulars of any recent improvements in booster design, such as limited cut-off, use of superheated steam, poppet valves, gear operation, suspension.*

| London & North Eastern Railway. | Canadian National Railways. |
|---|---|
| 1 engine of 4-4-2 express passenger type,<br>2 engines 2-8-2 mineral type. | |
| ... | 61 trailing truck. |
| ... | 6 tender truck. |
| Enabled faster running in sections. | No further information. |
| nabled engines to start with heavier load on gradients. | ... |
| e original design of booster gave no trouble but had the drawback that it was only suitable for starting and working at comparatively low speeds. | ... |
| ere is no information available as to the effect on the cost of maintenance of the booster, nor as to the coal consumption which could be ascribed to the booster as such.<br>e engines so fitted, however, do not show an increased coal consumption over the engines not so fitted. | ... |
| system of steam control for the gear operation has been used. The design has been altered to allow the booster to be cut in up to speeds of 20 miles per hour whilst the engine is running. | ... |

| QUESTION. | China. | | |
|---|---|---|---|
| | South Manchuria Railway. | Great Western Railway. | London Midla & Scottish Rail |
| Chapter VII. — **H. Special alloy steels.** | | | |
| *Give particulars of alloy steel used in :* | Carbon vanadium steel. | None in use. | « Vibrac » ste |
| a) *Motion to lighten moving parts.* | Piston rod.<br>Side rod.<br>Main rod. | ... | Connecting rod<br>Coupling rod |
| b) *Frame, boiler, etc., to lighten dead weight.* | ... | ... | ... |
| c) *Springs, attaching specification.* | ... | ... | ... |
| *Analysis.* . . . . . . . . . . | Elastic limit :<br>42 kgr. per mm².<br>Tensile :<br>63.3 kgr. per mm².<br>Elongation 20 %.<br>Reduction of area 40 %. | ... | 50-60 tons tensi<br>20 % elongation<br>inches. |
| | Carbon : 0.45% to 0.55%.<br>Manganese 0.70 % to 0.95 %.<br>Phosphorus : 0.045 %.<br>Sulphur : 0.05 %.<br>Vanadium : 0.18 %.<br>Permissible variations for check analysis :<br>Carbon : 0.02 %.<br>Vanadium : 0.03 %. | ... | Carbon . . . .<br>Manganese . .<br>Nickel . . . . .<br>Chromium. . .<br>Molybdenum . . |
| *Heat treatment* . . . . . . . | ... | ... | ... |
| *In typical cases such as connecting rods and coupling rods, piston heads and pistons, give particulars of weight saved.* | ... | ... | ... |

| Great Britain and North of Ireland. | | | |
|---|---|---|---|
| ondon & North Eastern Railway. | Southern Railway. | Great Northern of Ireland. | London Midland & Scottish Railway (Northern Counties Committee). |
| Nickel chrome. | « Vibrac » steel. | No reply. | No trials. |
| Connecting rods.<br>Coupling rods.<br>1 lever for operating entre cylinder valve gear. | Connecting rods and valve motion rods. | .. | ... |
| ... | ... | ... | ... |
| ... | ... | ... | ... |
| 40-45 tons tensile.<br>18 % elongation.<br>timate breaking stress not less than 50 tons.<br>ld point not less than 40 tons. | Yield point 50 tons.<br>Maximum stress 60-70 tons.<br>Elongation 17.5 % on 2″ × 0.564.<br>Reduction in area 50 %.<br>Izod impact 40 ft.-lb. | ... | ... |
| rbon . . . 0.33 %<br>icon . . . 0.21 %<br>nganese . . 0.60 %<br>lphur . . . 0.032%<br>osphorus . . 0.039%<br>kel. . . . 3.42 %<br>romium . . 0.60 % | Molybdenum . . 0.6 %<br>Phosphorus . . 0.03%<br>Carbon . . . . 0.3 %<br>Sulphur . . . 0.04%<br>Silicon . . . . 0.15%<br>Nickel . . . . 2.5 %<br>Manganese . . 0.6 %<br>Chromium. . . 0.6 % | | |
| ... | Heat treated by makers to 850° C. and quenched in oil, then reheated to 600° C. and allowed to cool in still air. | ... | ... |
| ot less than 30 %. | Weight saved in connecting rods, etc., is about 30 %. | ... | ... |

| QUESTION. | Africa. | | |
|---|---|---|---|
| | Rhodesian Railways. | South African Railways. | Sudan Governm Railways. |
| Chapter VII. — H. **Special alloy steels.** *(Continued.)*<br>*Give particulars of alloy steel used, etc. :* | No special alloys used. | None in use. | None in us |

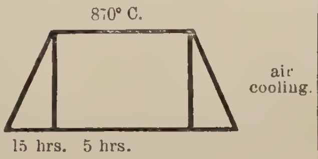
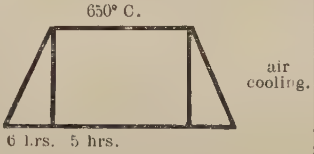
| QUESTION. | India *(continued).* | | | |
|---|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Peninsula Railway. | Madra Souther ratta R |
| Chapter VII. — H. **Special alloy steels.** *(Continued.)* | | | | |
| *Give particulars of alloy steel used in :* | No remarks. | ... | Special alloy. | Ni |
| a) *Motion to lighten moving parts.* | ... | Piston rods.<br>Coupling rods.<br>Connecting rods. | Side coupling rods. | ... |
| b) *Frame, boiler, etc., to lighten dead weight.* | ... | ... | ... | .. |
| c) *Springs, attaching specification.* | ... | ... | No details available. | ... |
| *Analysis.* . . . . . . . . | ... | ... | ... | ... |

| Australasia. | | Canada. | India. |
|---|---|---|---|
| New South Wales vernment Railways. | New Zealand Government Railways. | Canadian National Railways. | Ceylon Government Railways. |
| None in use. | None in use. | No reply. | None in use. |

| | | Japan. | | |
|---|---|---|---|---|
| th Indian ailway. | Federated Malay States Railways. | Japanese Government Railways. | | Government General of Chosen. |
| Nil. | Nil. | Nickel chrome. | Carbon vanadium. | None in use. |
| ... | ... | Connecting rod.<br>Piston rod. | Connecting rod.<br>Piston rod.<br>Crank axle. | ... |
| ... | ... | ... | ... | ... |
| ... | ... | Troubles due to hair cracks but on lowering working stress, no trouble experienced.<br>Yield point min. 47 kgr. per mm2.<br>Tensile 65-85 kgr. per mm².<br>Elongation min. 12 %. | Extraordinary difficulties in manufacturing crank axle.<br>Yield point 42 kgr. per mm².<br>Tensile, 63 kgr. per mm².<br>Elongation, 20 %.<br>Reduction in area, 40 %. | ... |
| ... | ... | Nickel 3.0 to 4.0 %.<br>Chromium 0.25 to 0.75 %.<br>Phosphorus not over 0.45 %.<br>Sulphur not over 0.45 %.<br>Carbon and manganese left to maker's choice. | Carbon 0.45 to 0.55 %.<br>Manganese 0.70 to 0.95 %.<br>Phosphorus not over 0.045 %.<br>Sulphur not over 0.050 %.<br>Vanadium min. 0.18 %. | ... |

| QUESTION. | India *(continued).* | | | |
|---|---|---|---|---|
| | Eastern Bengal Railway. | East Indian Railway. | Great Indian Peninsula Railway. | Madra Southern ratta Ra |
| Chapter VII. — **H. Special alloy steels.** *(Continued.)* | | | | |
| *Heat treatment* . . . . . . . | ... | ... | ... | ... |
| *In typical cases such as connecting rods and coupling rods, piston heads and pistons, give particulars of weight saved.* | ... | ... | ... | ... |

| QUESTION. | |
|---|---|
| Chapter VII. — **I. Light alloys.** | No railways reported use of light alloys. |

| | | Japan. | | |
|---|---|---|---|---|
| th Indian ailway. | Federated Malay States Railways. | Japanese Government Railways. | | Government General of Chosen. |
| ... | ... | Annealing 800° C., 2.4 hours.<br>Oil hardening — 800 to 840° C., 1.5 hours.<br>Quenched in oil 20° C.<br>Oil tempering, 600 to 650° C., 1.2 hours.<br>Tempered in oil 35° C. | 1st. treatment.  2nd treatment.  | ... |
| ... | ... | ... | ... | ... |

[ 625 .212 (.44) ]

# The Paris Orleans Railway Company's rail lubricator,

By Gaëtan DEVAUD,

ASSISTANT ENGINEER, LOCOMOTIVE DEPARTMENT.

Figs. 1 à 7, pp. 2822 to 2824.

(*Revue générale des chemins de fer.*)

The design of fittings intended to reduce the wear of locomotive wheel-flanges, has been followed with particular interest by the Orleans Company, owing to the numerous small-radius curves on their lines in the Central Massif.

A great number of these curves have à radius of only 150 metres (7 1/2 chains), and are run over by six-wheel coupled tank engines of the *Mikado* type, having a long wheel-base [10.79 m. (35 ft. 4 13/16 in.)]. The rapid wear of the flanges of certain wheels of these engines is a source of great expense, which, further, complicates the carrying-out of the periodic overhauls in the depots in the districts concerned.

On these lines, corresponding wear is also manifest on the flanges of carriage and wagon wheels, and on the inside faces of the rails on the curves. The wear of the rails results in frequent and very troublesome and costly renewals.

The reduction of all such wear is therefore a matter of great importance (1); and with this object numerous systems of oiling the flanges have been tried for a considerable time on the lines in question.

Up to the present, none of these systems has given really satisfactory results, and their use has had to be abandoned at the end of a more or less extended time of experiment or service.

Owing to the importance which the Orleans Company attaches to the perfecting of an apparatus of this sort, the experiments have however been continued with very particular care.

Engines both fitted, and not fitted, with lubricators for the purpose of comparison, were so chosen that the two groups of engines had tyres of sensibly the same hardness.

The supply of oil was fixed at a value definitely greater than that laid down by the maker, so as to ensure ample lubrication.

In spite of all these precautions, the results were always plainly inadequate; on some of the engines fitted with lubricators the amount of wear was identical with that on engines non-fitted.

In view of these abnormal results, the exact causes of the defective lubrication of the wheel flanges was investigated by watching very closely the working of the lubricators in service. With this object, an observer was placed on an engine fitted with lubricators, so that he could watch a lubricator and its corresponding wheel the whole time.

---

(1) See the *Revue Générale* of November 1927, page 527, and of June 1928, page 472.

The following observations were made:

The lubricators worked perfectly well, and when running along a straight stretch of line, the wheel flange was covered with a thin film of oil as intended. But when the machine came to a curve of small radius, the oil was cleared away after the first few revolutions of the wheels, through the very great pressure between the rail and the corresponding flange, and the rest of the curve was negotiated dry. That is, the oil disappeared as soon as it became needed.

To remedy this fault, it would have been necessary to increase the already large quantity of oil fed by the lubricators, so that they could re-form the oil-film at each revolution of the wheel : but the result would have been a prohibitive consumption of oil.

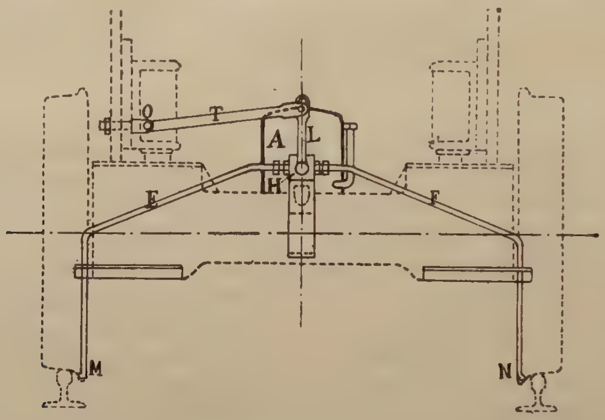


Fig. 1.

An attempt has been made to reduce this consumption by making the flow intermittent, by means of an arrangement with which oil is fed only on the curves. Several lubricators have been got out on this principle, but their action has always been unsatisfactory.

The failure of these attempts led to the conclusion that it was necessary to attribute the lack of success to the actual principle of oiling the flanges, rather than to a defect in design of the lubricators tested.

The Orleans Company in consequence, gave up tests with such types of apparatus, and directed its researches towards the lubrication of the rails.

This method of oiling, already recognised and employed by various foreign railways, has been made practical and economical by means of an apparatus carried on the locomotive, as shown in figures 1 and 2.

This apparatus is due to the collaboration of Messrs Teindas, leading locomotive driver, Riboulet, chief foreman, and Monfort, assistant foreman; all from the Ussel sheds, the engines from which suffer particularly from the wear in question.

The apparatus is made up of the following parts :

1. A reservoir of oil, A, connected by the pipe, B, to the compressed air reservoir on the engine.

2. A vaporiser, C, in which the oil is

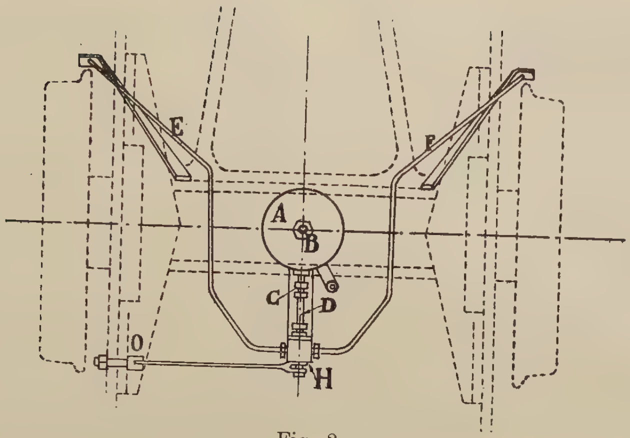


Fig. 2.

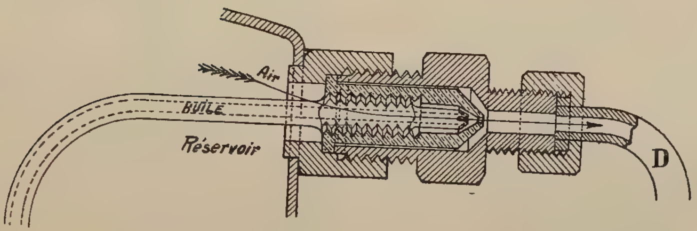


Fig. 3.

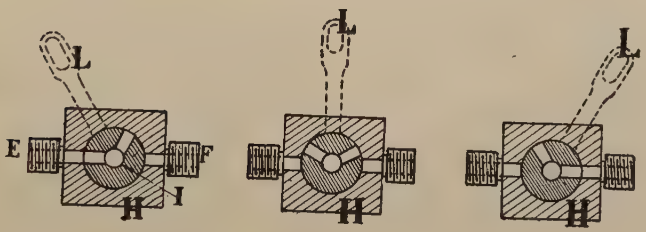


Fig. 4 à 6.

vaporised and mixed with the compressed air. The oil-vapour so formed flows down the pipe D. (fig. 3).

3. A three-way cock, H (figs. 4 to 6). The oil vapour arrives by the central orifice, I, and is directed into one of the pipes, E, and F, according to the position of the lever of the cock.

In the middle position, the cock is shut, and the working of the vaporiser is stopped.

The two pipes, E and F, end in jets, M and N (fig. 1), placed near the inner surface of the rail, as shown in figure 7.

This figure shows that the end of the pipe is so arranged that when viewed from the front, it is masked by the contour of the flange; the pipe is consequently well protected, while the locomotive is running, from accidentally coming into contact with any track fitting.

The internal shape of the jet (fig. 7) has been designed to give the jet of oil the most suitable form.

All the apparatus is carried on the frame of the pony-truck of the locomotive. Since there are no springs between the truck frame and the wheels, the position of the jet, once decided upon, remains fixed relative to the rail (at least as regards height).

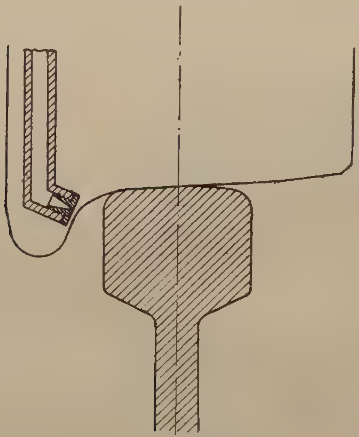


Fig. 7.

The cock H (fig. 1), is operated by the rod T, which is fastened at one end to the lever L of the cock, and at the other to the main frame of the locomotive, at the point O.

When the frame of the pony-truck is in line with the rest of the locomotive, that is, the locomotive is travelling along a straight line, the cock H is closed. When the locomotive takes a curve, the cock opens under the effect of the displacement of the pony-truck, and the oil-vapour is sent along one of the pipes E or F. The openings of the cock are arranged so that this oil-vapour is directed upon the outer rail of the curve.

Before giving the results obtained with this apparatus, let us point out that the nozzles M and N, are usually placed not in front of the first wheel of the locomotive, but between the first and the second wheels. If, indeed, these nozzles were placed in front of the first wheel, they would be damaged each time the locomotive ran through points set for the opposite direction to that in which it was travelling, for the nozzles would strike, before the flanges, the switch-rail of the point which the locomotive has to open in order to pass.

This difficulty is avoided by placing the nozzles between the first two wheels of the locomotive; for in every case, one or other of the flanges of these two wheels holds open the switchrail, which would otherwise tend to grip the nozzle against the rail.

### Results.

The apparatus has given good results. Through its use, the wear of flanges has been reduced by about 90 %. In all the depots in the mountainous districts, it was necessary, before the apparatus came into use, and especially in summer-time, to change many pairs of wheels, the flanges of the coupled wheels being found to reach the limit of wear after running about 20 000 kilometres (12 430 miles). After fitting the lubricators, no more changes have been made, and all the engines can run their normal mileage (about 70 000 kilometres, *i. e.* 43 500 miles), before repair, without the flanges having reached their limit of wear.

These results have been obtained with

a very small number of lubricators in service. It is not, in fact, necessary to fit every engine working over a given stretch of line. It has been found that the oil applied by one engine remains for a long time after the passage of that engine; and that many following trains benefit by it. Experiments made over lines thus oiled have shown that successive trains, travelling behind a train drawn by a locomotive fitted with a lubricator, had all the wheel-flanges both of the engines and carriages lightly covered with oil after running through a curve; the number of such succeeding trains varies according to the nature of the line, and the atmospheric conditions, and is usually about six.

As a matter of fact, the results shown above have been obtained with 24 lubricators distributed among 186 locomotives, thus giving one lubricator to every 8 locomotives.

This oiling of all the wheels of the trains has also effected a remarkable reduction in the additional tractive resistance due to curves; this fact was realised immediately after the introduction of the lubricators. The value of this reduction and the corresponding amount of fuel saved have, however, not been exactly determined the careful experiments needed for this purpose not having been made.

The consumption of oil by one of these lubricators is about 3 kgr. per 100 kilometres (10.6 pounds per 100 miles), and the costs of upkeep are negligible.

It has not been possible to determine exactly what saving has been obtained by the reduction of flange wear of carriages and wagons; to do this it would be necessary to make the vehicles travel constantly over the same lines, whereas they frequently have to run over lines not oiled.

It has been difficult also to appreciate the effect of oiling on the life of the rails; it can however be estimated that their life will be at least doubled.

The use of the apparatus just described, by the three sources of saving it gives, on locomotives, carriages and wagons, and rails, appears to be the solution of a long standing problem; and its use is to be extended without delay on all those lines of the Paris-Orleans Railway Company, upon which it is considered to be necessary.

# CURRENT PRACTICE.

[ 625. 234 (.42) ]

## Water heating in sleeping cars.
## London & North Eastern Railway.

Figs. 1 to 3, pp. 2827 to 2829.

In pursuance of the Company's practice to eliminate gas from all main line trains, Mr. H. N. Gresley, the Chief Mechanical Engineer, has fitted a number of London & North Eastern Railway sleeping cars with special electrical apparatus for the heating of the water required both in the berths and in the attendants' compartment.

Two systems have been developed. In the first the water is pre-heated at the terminal stations by connection with the high voltage ground supply, the current en-route being provided from the train lighting dynamo.

The second system is entirely self-contained, being independent of both lighting circuit and ground mains. The layout is shown on the accompanying diagrams (figs. 1 to 3) which are self explanatory. A 50-volt, belt driven, direct current generator having an output of 60 amperes is suspended from the underframe, together with a battery of 25 traction-type cells of a capacity of 225 ampere-hours. The dynamo is able to give a minimum output of 60 amperes at approximately 760 revolutions per minute.

When the train is standing and until a speed of 30 to 35 miles per hour is attained, the necessary current is supplied from the battery; after that speed is reached the current is supplied direct from the generator. The current passes through a two-way switch to a tea urn of 2 3/4 gallons capacity or, by way of a contactor switch to the main water heater; when the switch is in the mid position the current passes direct to the battery.

The main heater and circulating tank for supplying hot water to the berths has a total capacity of 21 gallons and is heated by two immerser heaters, the temperature being controlled by means of a thermostat which operates the contactor switch, cutting off the current when the temperature of the water reaches 150° F. and cutting in again at 135° F. An auxiliary steam coil is fitted in the boiler and is connected to the steam heating main pipe for use in case of emergency. The steam supply is also thermostatically controlled.

A portable kettle and saucepan is provided to enable the attendant to boil small quantities of milk when necessary.

The development and installation of the apparatus has been carried out at the Doncaster Works.

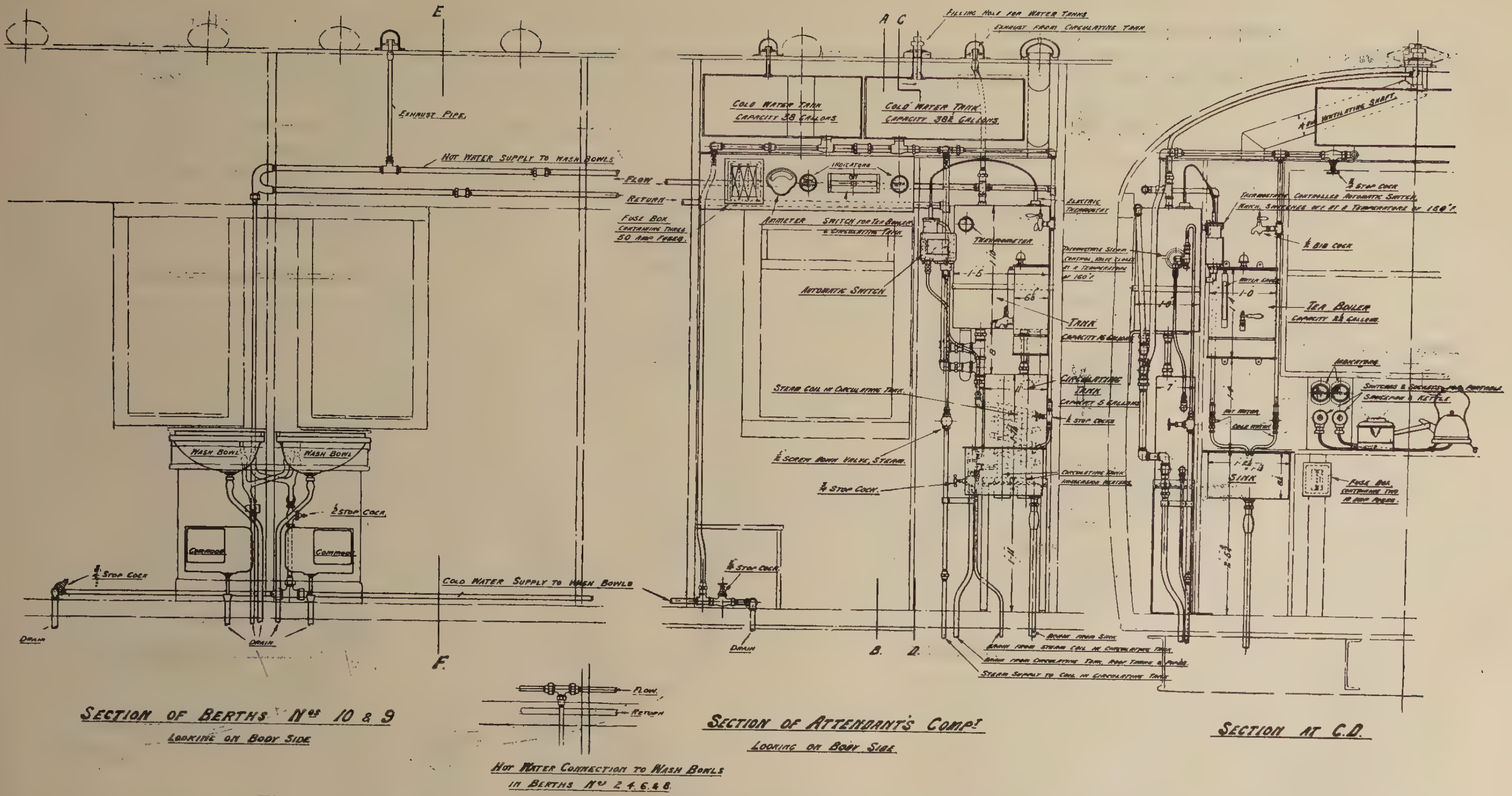
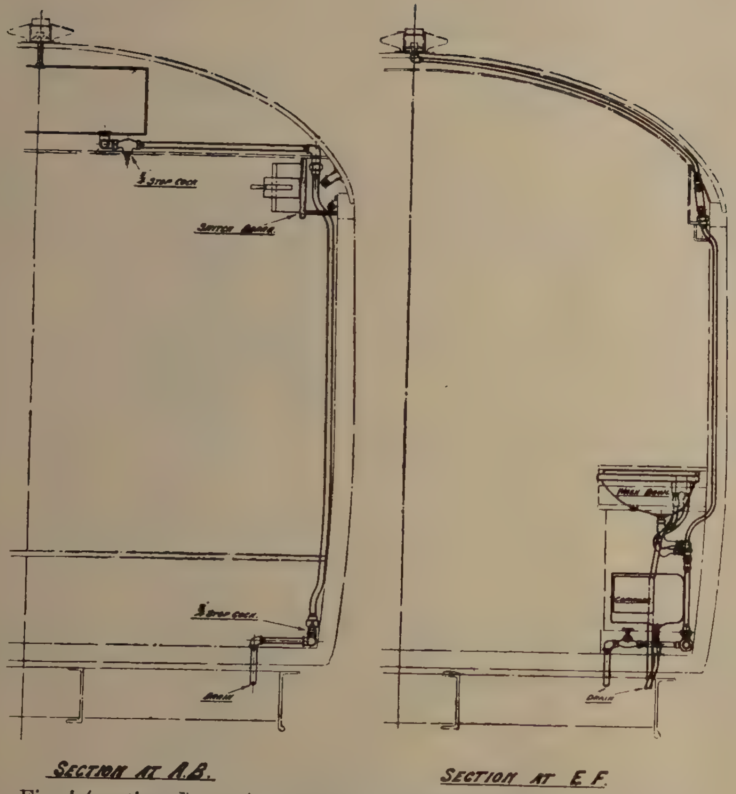

E
F
A C
B.
D.
Filling Hole for Water Tanks
Exhaust from Circulating Tank
Exhaust Pipe.
Hot Water Supply to Wash Bowls
Flow
Return
Fuse Box Containing Three 50 Amp Fuses.
Cold Water Tank Capacity 38 Gallons
Cold Water Tank Capacity 38½ Gallons
Indicators
Ammeter
Switch for Tea Boiler & Circulating Tank
Automatic Switch
Thermometer
Electric Thermostat
Tank Capacity 16 Gallons
Circulating Tank Capacity 5 Gallons
¾ Stop Cocks
Steam Coil in Circulating Tank.
¾ Screw Down Valve, Steam.
¾ Stop Cock.
Circulating Tank Immersion Heaters
Drain from Sink
Drain from Steam Coil in Circulating Tank
Drain from Circulating Tank, Body Tanks & Pipes.
Steam Supply to Coil in Circulating Tank
Thermostatic Steam Control, Valve Closes at a Temperature of 160°F
Thermostatic Controlled Automatic Switch, Which Switches off at a Temperature of 180°F.
¾ Stop Cock
¾ Bib Cock
Ventilating Shaft
Water Gauge
Tea Boiler Capacity 2½ Gallons
Indicators
Switches & Sockets for Portable Saucepan & Kettle
Hot Water
Cold Water
Sink
Fuse Box Containing Two 10 Amp Fuses.
Wash Bowl
Wash Bowl
½ Stop Cock.
Commode
Commode
¾ Stop Cock
¾ Stop Cock
Drain
Drain
Drain
Cold Water Supply to Wash Bowls
1-0
1-6
1-5
6½
8
1-10
1-11
7
1-2½
2-5½
Section of Berths Nos 10 & 9
Looking on Body Side
Hot Water Connection to Wash Bowls in Berths Nos 2, 4, 6 & 8.
Section of Attendant's Compt
Looking on Body Side
Section at C.D.

Fig. 1. — Arrangement for heating water by electricity in sleeping cars. — London & North Eastern Railway.



SECTION AT A.B.

SECTION AT E.F.

Fig. 1 (*continued*). — Arrangement for heating water by electricity in sleeping cars. — London & North Eastern Railway.

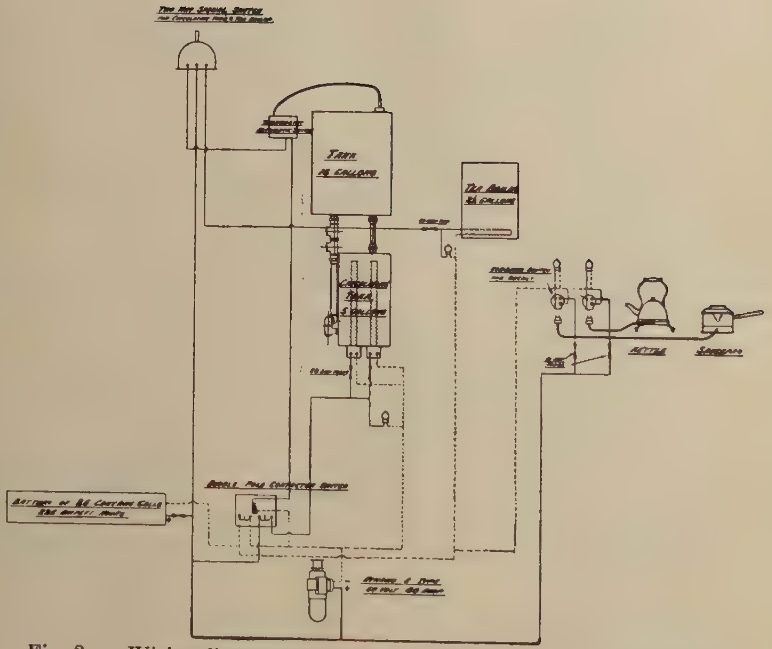


Fig. 2. — Wiring diagram for water heating by electricity in sleeping cars. London & North Eastern Railway.

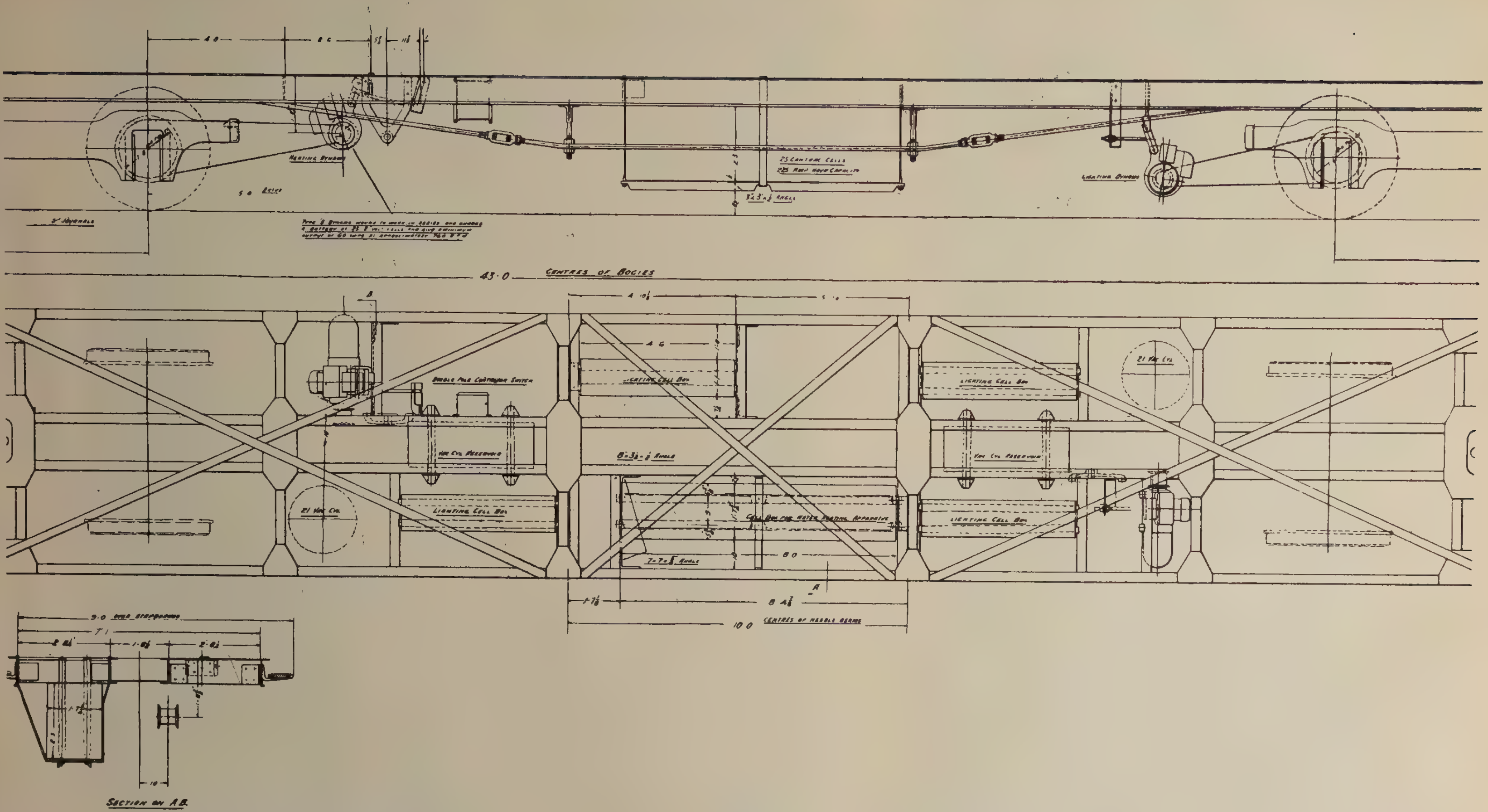


Fig. 3. — Arrangement of 60-foot steel underframe for single sleeping car, shewing position of additional dynamo and cell box for heating hot water circulating boiler, etc. London & North Eastern Railway.

# MISCELLANEOUS INFORMATION

[ 625 .246 (.43) ]

## Carriage disinfection plant at Potsdam Shops.

Fig. 1, p. 2831.

(*The Railway Gazette.*)

In 1900 the German Parliament passed a law to improve the methods of dealing with contagious diseases, and other common infections, and amongst other things the duty was specially laid upon the Railway Administration of preparing measures for use on the occasion of an outbreak of any of the common infectious diseases, and also for the treatment of railway coaching stock in which infected persons had travelled.

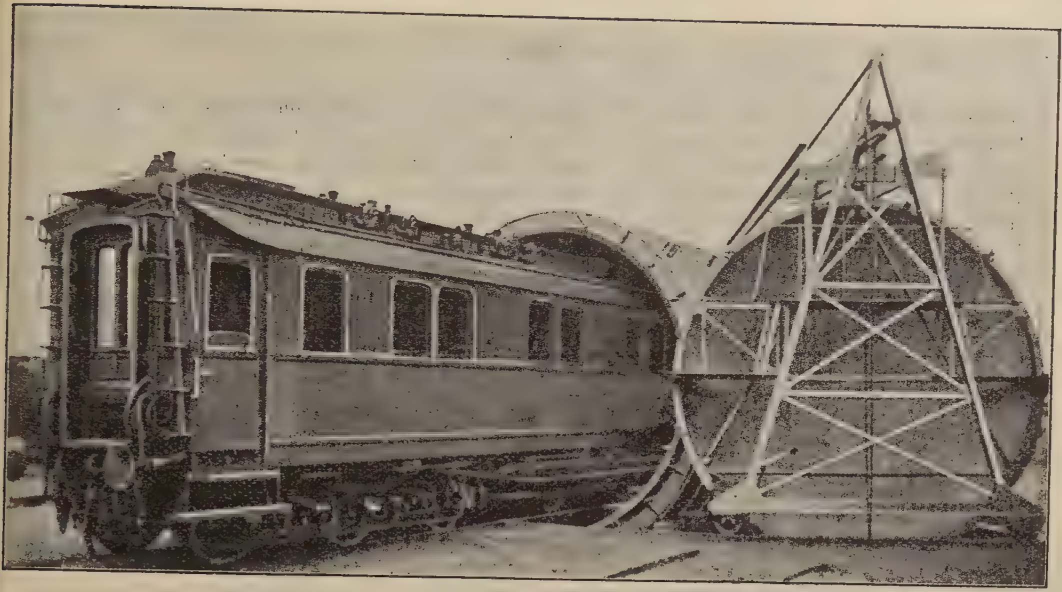
The old method of dealing thoroughly with a coach in the repair shops was very costly, and involved the removal of all upholstery and partitions, disinfection and replacement, resulting in the vehicle being out of service for long periods. It also had the risk of the infection taking root amongst the staff of the works; in addition to this it was not entirely satisfactory as regards results. It speedily became clear that a special plant of some kind would have to be built to fulfil the legal requirements.

While methods of complying with the law were being considered, two other factors came up for consideration, *i.e.*, the necessity of finding a method for dealing with the « livestock », which were prevalent in the upholstered coaches used in the traffic with Russia and other Eastern European countries, and the desirability of having a plant for drying the floors of restaurant-car kitchens and dealing with damp in carriage roofs caused by roof leakages, and leakages caused by the action of frost on the hot water heating equipment of sleeping cars. In these two cases the old method of drying the coaches in the paint shops was very inconvenient, as it not only led to their being absent from traffic for several days, but also delayed the work of the carriage painters.

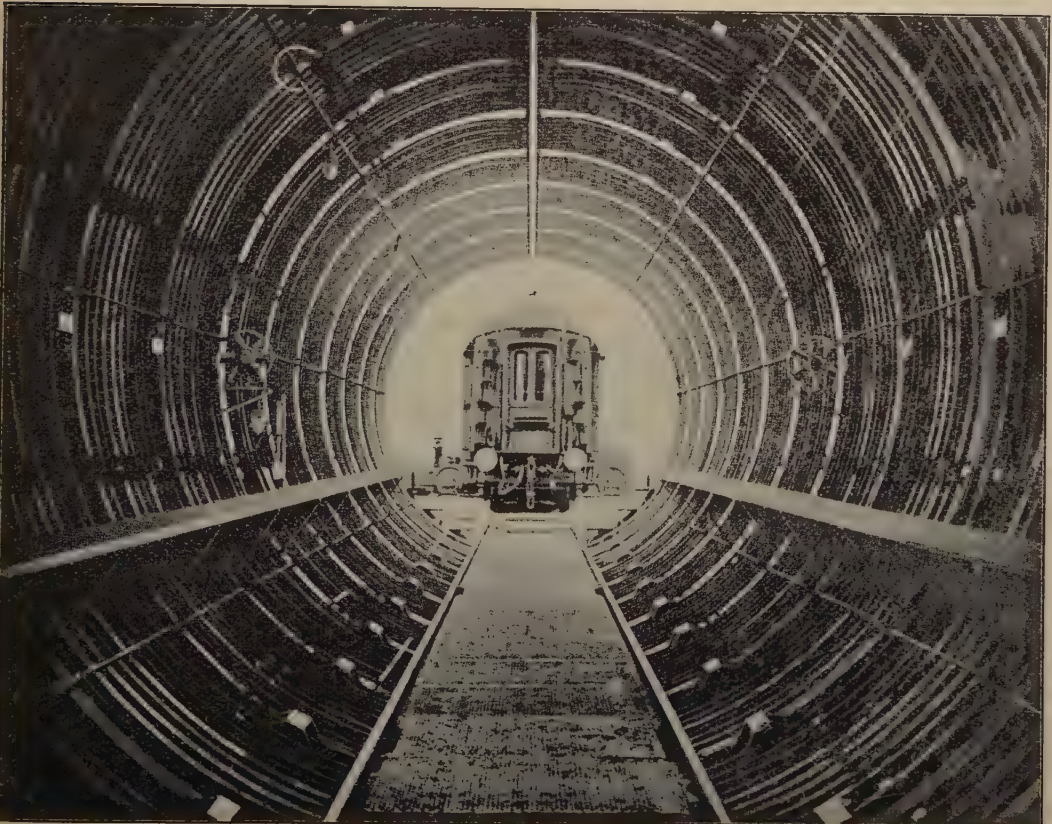
These facts were put to the firm of Julius Pintsch, who had previously built apparatus for ship disinfection in Hamburg, and they were invited to draw up and submit plans for a plant capable of dealing with complete coaches. Experiments had shown that microbes can only be killed with certainty when a temperature of 100° C. (*i.e.*, the boiling point of water) is reached. The use of vaporised formalin increases the effectiveness, but had the disadvantage that it did not get in everywhere.

Two difficulties now presented themselves. To heat up coaches to a temperature of 100° C. was not to be thought of owing to the damage to paintwork, etc. How was the formalin to be forced to all cracks and crevices? The method adopted was to attain conditions under which water boils, but with a lesser degree of heat; it therefore became necessary to reduce the air pressure, and the result of the experiments having shown that a maximum of 50° C. (122° F.) of heat did no material damage to the coaches, this temperature was decided upon as the limiting factor for heat and the apparatus had to be designed so that the air pressure could be reduced accordingly and water boiled to 50° C., conditions under which organic life becomes impossible. At the same time the second difficulty was surmounted as the inrush of air on restoration of normal atmospheric pressure would carry the formalin charged air into the crevices.

The firm of Pintsch designed and subsequently built the apparatus shown in the illustrations. As seen, a cylindrical form was adopted, fitted with a large swing door, capable of taking a full-sized corridor coach. This cylinder is fitted with steam heat piping so that the cylinder can be heated up to a tempe-



Carriage passing into cylinder.



Interior of cylinder.

Fig. 1. — Carriage disinfection plant, Posstdam Works, German Railways.

rature of 40° to 50° C. (104 to 122° F.). It is then possible to exhaust the cylinder until the pressure has been reduced by 700 to 740 mm. (27.56 to 29.13 inches) of mercury. By this combination of a moderate temperature and a low pressure it is possible to extract all water, etc., as, under these conditions, water fluids vaporise. The combination therefore secured a practicable method of dealing with infected coaches, as the temperature was not sufficiently high to damage the paintwork of the coach, while the low-pressure secured all the advantages that a high temperature could have secured. All living bodies and eggs are destroyed through a process akin to mummification without damage to upholstery, leather, paint, wood, or polish. If necessary, formalin can also be evaporated in the cylinder during the period of disinfection, and the vapour quickly fills the whole apparatus by convection currents, the fans at first installed being found unnecessary.

The plant is capable of dealing with one vehicle every 12 hours, but in practice it is found that this high degree of user is not necessary, and the output of the plant is one car per day on the average, The coach is put in and the first two or three hours are employed in heating up the cylinder and reducing the temperature until the constant conditions required are arrived at. These conditions are maintained for a period of about four hours and the coach is then, as a rule, left to cool off during the night.

The cylinder is constructed of cast iron and is 25 m. (82 ft. 1 in.) long by 5 m. (16 ft. 5 in.) in diameter, and so designed that a coach weighing 60 tons can be run in. The factors worked to were 220 kgr. (3 130 lb. per sq. inch.) per cm$^2$ for air pressure and 110 kgr. per cm$^2$ (1 565 lb. per sq. inch) for train weight, the total air pressure to be resisted being over 4 000 000 kgr. (8 820 000 lb.) of which nearly 3 3/4 millions are on the cylinder itself and nearly 300 000 kgr. on the door. The weight, including the small crane for swinging the door into position, is 135 000 kgr. (297 600 lb.).

The cylinder rests on pediments so arranged that the specially constructed rails are supported directly over them, and the load transmitted directly to the foundations in order to avoid any possibility of distorting the cylinder. The door, which weighs 4 tons, is swung into position, the rail length at that point being removable to allow the movement. This operation is performed by one man, who afterwards clamps the door fast. Fresh steam is taken from the works' boilers and a small pumping plant is provided for exhausting the cylinder. The steam is distributed through one long tube at the top of the cylinder which has 252 semi-circular tubes branching away from it and leading into a condensation tube at the bottom, which runs off through a self-acting drainage valve into the outside air. The length of the tube is 19.060 m. (62 ft. 7 in.), giving 210 m$^2$ (2 260 sq. feet) heating service. This enables a temperature of 60° C. (140° F.) to be reached from one of — 15° C. (5° F.). A temperature of 50° C. (122° F.) can be reached in one hour and a coach is thoroughly heated in five hours.

The vacuum is created by a 20-H.P. auxiliary electric motor and the cylinder can be exhausted in two hours. The exhaust air is led either under the grate of the furnace or into the chimney stack, so that all infectious air is thoroughly sterilised before being released.

The plant cost about £4 000 to construct and was brought into operation in 1909, since when it has had a very successful career. It was calculated then that the cost, reckoning one coach per day, was 35 sh., including depreciation and overhead charges.

On taking over, a test was carried out and in 2 1/2 hours an air pressure reduction of 740 mm. (29.13 inches) was made, after which the cylinder was left for over two days, during which period the rise through leakage was not more than 40 mm. (1.575 inches).

Experiments have shown that fleas and ticks in a glass tube stopped with wadding and bound up in a linen bag were quite dead at the end of the test, and subsequent experience has proved that bad smells in dining-car kitchens can be eliminated after 24 hours in the cylinder.

[ 385 (09.2 ]

# OBITUARY.

## Raffaelo de CORNÈ,

Former General Manager of the Italian State Railways and a former President of the Supreme Council of the Public Works Department of the Kingdom of Italy;
Delegate of the Italian Government to the 8th Session (Berne-1910) of the International Railway Congress Association;
Vice-President of the local organising Committee of the 9th Session (Rome-1922);
Honorary Vice-President over the full Meetings of the 9th Session;
Life Member of the Permanent Commission of the International Railway Congress Association.

We have learnt with the deepest regret of the death of Signor Raffaelo de Cornè, at Rome on the 25th of August 1929.

Born in 1852 at Capua he obtained the diploma of engineer at an early age after having brilliantly completed his studies at the University of Naples.

He entered the Corps of Civil Engineers immediately afterwards and, as a result of his ability, his promotion was rapid.

In February 1915, he was appointed by the Italian Government, Manager of the State Railways. He had to meet the difficulties that arose on the railways during the preparation for and during the participation of Italy in the European war.

During this period and the no less difficult post war situation, Signor de Cornè unstintedly spent his incomparable ability, his experience, energy and sound judgment.

In 1920, on leaving the management of the State Railways, he was made President of the Supreme Council of Public Works which post he retained until 1926, when owing to the age limit he retired.

Signor de Cornè was nominated member of the Permanent Commission of the International Railway Congress Association in March 1920. He always displayed a keen interest in the work of the Association.

Signor de Cornè took a very active part in the organisation of the IXth Session (Rome, 1922) of the Association, at which time he was General Manager of the Italian State Railways. He was honorary Vice-President of the said Session and presided over the full meetings of the Congress with unusual ability and tact. He was nominated life member of the Permanent Commission on this occasion.

The Association will faithfully preserve the memory of such devoted collaboration, and offers its most sincere sympathy to the family of the deceased.

*The Executive Committee.*

[ 385 (06 111 ]

# OFFICIAL INFORMATION

ISSUED BY THE

## PERMANENT COMMISSION

## of the International Railway Congress Association.

### Meeting of the Permanent Commission held on the 6 July 1929.

The Permanent Commission of the International Railway Congress Association met on the 6 July 1929 at the Railway Headquarters at Brussels, Mr. E. Foulon being in the Chair.

Several members of the local organising Committee of the Madrid Congress (1930) attended the meeting.

* * *

I. — The statement of accounts for the year 1928 which had been checked by an auditor, was approved as well as the proposed budget for the year 1929.

The variable part of the annual subscription payable by the member Administrations (art. 17 of the statutes) which, in 1925, was fixed at 0.10 gold-franc per kilometre operated, having become insufficient owing to additional expenses, and in particular to those relating to the Madrid session, it was decided to increase it to 0.15 gold-franc as from the 1 January 1930, that is to 3/4 of the maximum (0.20 gold-franc) authorised by the statutes.

* * *

II. — Attention was called to the fact that, at the meeting held on the 1 July 1925, the full meeting of the London Congress authorised the Permanent Commission, in accordance with the ordinary rules of procedure, to admit Germany to the countries included in the International Railway Congress Association, and to increase at the same time, by 6 to the maximum, the number of members of the Permanent Commission.

The German Government and the « Deutsche Reichsbahn Gesellschaft » (German Railway Company) have expressed their willingness to become members, and the Permanent Commission has acted their affiliation to the Association.

* * *

III. — Messrs. Braem, Leroux, and Schwob having resigned as Members of the Permanent Commission owing to their having ceased to belong to the Member Administration or to the Government which they represented, have been replaced by :

Messrs. Rulot, Chief Mechanical Engineer of the Belgian National Railway Company;

Dautry, General Manager of the French State Railways;

Grimpret, General Manager of Railways at the French Ministry of Public Works.

Mr. Tamaki, Manager of the Berlin Office of the Japanese Government Railways, who has given up the management of this office in order to return to Japan, has, in agreement with the Japanese Minister of Railways, been replaced as Member of the Permanent Commission by his successor, M. Hirayama.

Mr. Besser, Ministerial Councillor at the Ministry of Communications at Berlin, Mr. Dorpmüller, General Manager of the « Deutsche Reichsbahn Gesellschaft », and Mr. Wolf, Privy Councillor and Manager at Headquarters of the same Company at Berlin, have been nominated Members of the Permanent Commission.

The names of the three other persons who will be nominated to fill the remaining vacancies allotted to the German Delegation will be announced at a later date.

The following were also made Members of the Permanent Commission :

Messrs. van Manen, Manager of the Netherlands Railways;

Djouritchitch, General Manager of the State Railways of the Kingdom of the Serbs, Croates, and Slovenes, and

von Willich, B. Sc., A. M. I. C. E., Advisory Engineer at the Office of the High Commissioner for the Union of South Africa,

as new Members which it was decided to appoint — subject to ratification by the Congress of Madrid — at the Meeting of the Permanent Commission held on the 30 June 1928.

⁂

IV. — The Meeting considered the arrangements made by the local organising Commission of the Madrid Congress to assure the success of the Session and especially as regards accommodation, which will meet in every way the requirements of the Congress, the organisation of the General Office of the Session, the printing of the daily *Journal*, the registration cards, the badges, the travelling facilities granted by the Spanish Railways, the excursions, etc.

⁂

V. — The publication in the *Bulletin* of the Reports dealing with the questions to be discussed at the Madrid Congress is well advanced, and except in case of force majeure, this work will be completed in February 1930.

⁂

VI. — The Member Administrations and the Organisations Affiliated to the Association, have been requested to state the questions which they consider should be discussed at the 1933 Session.

A provisional programme will be submitted to the next meeting of the Permanent Commission (February 1930).

⁂

VII. — The following changes have taken place in the Membership of the Association since the last meeting, other than the admission of the Germain Government and of the « Deutsche Reichsbahn Gesellschaft » mentioned above :

### ORGANISATIONS.

*Admission :*

Union of private Swedish Railways (Svenska Järnvägsforeningen) which includes 113 private Railways operating 9 900 kilometres (6 152 miles) of railways, of which more than 5 500 (3 418 miles) belong to Companies not at present Members of the Association.

### ADMINISTRATIONS

*Admissions :*

Sorocabana Railway (property of the State of St. Paul, Brazil), 2 165 km. (1 345 miles);

West of Spain National Railway Company, 1 587 km. (986 miles);

Karlskrona-Växjö Private Railway, 114 km. (71 miles);

Uppsala-Norrland Operating Combine, of the Uppsala-Gäfle, Ostkustbanan and Gäfle-Ockelbo Railways (Uppsala Norrland Trafikforbundet) 505 km. (314 miles);

Kristianstad-Hässleholms Railway, 116 km. (72 miles).

*Readmission :*

Salentino Railway, Italy, 242 km. (150 miles).

### ALTERATIONS

The Portuguese State Railways (1 379 km. (857 miles), are at the present time operated by the Portuguese Railway Company, which is already included among the Member Administrations. The length of the Company's System has grown to 2 419 km. (1 503 miles).

⁂

The following three Administrations :

Madrid to Caceres and to Portugal and the West of Spain, 777 km. (483 miles);

Medina del Campo to Salamanca, 77 km.(48 miles);

Medina del Campo to Zamora and from Orense to Vigo, 372 km. (231 miles);

have been operated as from the 1st January 1929 by the new West of Spain National Railway Company which, as mentioned before, has asked to be made a member of the Association.

### RESIGNATIONS

Östra Skånes Railway (in liquidation), 206 km. (128 miles);

Rome-Milan-Bologna Light Railways and Tramways (no longer directly operated), 31 km. (19 miles);

Lehigh Valley Railroad, 2 195 km. (1 364 miles);

Ulster and Delaware Railroad, 208 km. (129 miles).

The last two Companies advise us that their resignation has been decided upon as a « measure of economy ».

The Southern Railway of the United States not having replied to any communication from the Association since 1923, although repeatedly written to, is considered as having resigned [10 560 km. (6 562 miles)].

At the present time the Congress Association includes 224 Administrations with 577 593 km. (358 906 miles) of track which represents an increase of 53 961 km. (33 530 miles) as compared with 1928.

⁂

His Excellency Abdul Hamid Pacha Soliman, Egyptian Minister of Communications, Member of the Permanent Commission, has expressed the wish to see the 12th Session of the Railway Congress held at Cairo.

The Permanent Commission has agreed to submit this proposal to the Madrid Congress, at which the subject should be discussed in accordance with the statutes.

⁂

The Meeting noted the contract entered into with the International Publishing Corporation as regards the Publicity in the *Bulletin of the International Railway Congress Association*, and agreed that the contract was advantageous to the Association.

Is was decided that the next meeting of the Permanent Commission should be held in Brussels in February 1930 with a view more especially to dealing with the final arrangements for the Madrid Session.

| P. Ghilain, | E. Foulon, |
|---|---|
| *General Secretary.* | *President.* |